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McIntire - Stennis
Cooperative Forestry
Research Program

FORESTRY RESEARCH PROGRESS IN 1972

COOPERATIVE STATE RESEARCH SERVICE · U.S. DEPARTMENT OF AGRICULTURE



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Preface

The subdivisions of the McIntire-Stennis Forestry Research Progress Report for 1972 follow the pattern of the current regional-national long range research planning organization. Thus, the main headings are the same as the titles of the forestry research program groups, including numbers of these groups. The research problem areas (RPA's), including their numbers, are arranged within the nine forestry group programs. Selections of the research projects featured in this report have been made by the participating institutions. The supporting narratives of progress, in some cases accompanied by a photograph or chart, are fewer in number than in the past 2 years. But they are distributed among the research problem areas to represent the broad range of research within the McIntire-Stennis program.

Long range regional and national research planning by the Association of State College and University Forestry Research Organizations (ASCUFRO), the National Association of State Universities and Land Grant Colleges (NASULGC), and the U. S. Department of Agriculture is a continuous process. ASCUFRO and the Cooperative State Research Service work closely with the Forest Service in this planning system to develop the forestry elements of the overall agriculture and forestry research program. Research planning task forces also have members from forest industries. Effectiveness in research planning by ASCUFRO is reflected by the breadth and the points of emphasis of the research reported for 1972.

The printing costs of this report were borne by the Association of State College and University Forestry Research Organizations. Copies may be obtained by addressing a request to: Division of Information, Cooperative State Research Service, U. S. Department of Agriculture, Washington, D. C. 20250.

The photograph on the front cover is courtesy of Colorado State University.

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Introduction

This year marks the completion of the first decade of the McIntire-Stennis Cooperative Forestry Research Program. With 10 years of history now behind us, a brief review of accomplishments and progress is appropriate.

We have matured to the point where we have effective forestry research programs in each of our 50 States. The Program has contributed materially to the knowledge base upon which vital forestry and natural resources management decisions must be made. This has happened because McIntire-Stennis projects have led to closer cooperation among public resource agencies, private industry, conservation groups, and forestry schools. The injection of Federal funds on a matching basis provided a multiplier effect in graduate level programs. Those programs have been widened and deepened to the point where forestry schools can begin to satisfy the Nation's immediate need for researchers, teachers, and administrators.

The McIntire-Stennis Program has grown from a Federal funding level of \$1 million to this year's congressionally authorized level of \$6.4 million. Based on the expression of confidence implicit in that increase, the future for forestry research should be bright. Based on the acknowledged progress in the university component of such research, much of it attributable to the McIntire-Stennis Act, the forecast for the next 10 years should be favorable. During that time, there is a clear necessity for the level of research activity in the universities to better balance the dramatic increase in teaching activities.

During the last few years, the Nation's forestry schools have experienced an unprecedented increase in enrollments, at both undergraduate and graduate levels, at a time when university enrollments in general have remained relatively constant or have actually declined. National projections of the number of professionals needed in the next decade in forestry and related fields are very high. Much of this demand for professional knowledge is the result of increased public concern for the environment. This environmental awareness is more than just a catch phrase. For the first time in many decades, the concerns of society are identical to those of the professional forester. The natural resource priorities outlined by President Nixon and the expressed desires of society point up unusual opportunities and great challenges to the entire forestry profession. Meeting those challenges will require building upon the experience we have gained in forestry research over the last 10 years as well as redirection of our research efforts toward new problems.

This report was compiled by Dr. John W. Andresen, Southern Illinois University and Dr. Boyd W. Post and Dr. Aubrey E. Wylie, Cooperative State Research Service, U. S. Department of Agriculture, Washington, D. C. 20250.

Three areas of forestry research are especially in need of continued and expanded effort in the immediate future: (1) timber management, harvesting, and utilization, (2) forest land use planning, and (3) quality of the forest resource environment. Intensified and improved management techniques must be applied to private as well as to public forest land. New and imaginative harvesting methods are a necessity if environmental quality considerations are to be met. Regeneration of cutover and burned areas and harsh sites is required to maintain growing stock as well as for aesthetic purposes. More complete utilization of timber is necessary not only to produce more fiber but also to reduce the volume of debris left in the forest. Full attention must be directed to multiple-use forest management to achieve national objectives.

A major research thrust in forest land use planning is imperative. Recreational use of forest lands is increasing at an unprecedented pace. Many of the diverse uses are becoming belligerently incompatible and research is needed on which to base management systems that permit what are not conflicting uses. Research is also urgently needed to develop acceptable alternatives to the limiting concept of "pure" wilderness. Carefully designed trail systems based on research results are needed to accommodate hikers, horseback riders, skiers, and a variety of off-road vehicle users. Such trails are essential both to protect forest land and to reduce conflict among users. Forest land zoning should be considered as a management tool in the location and development of winter sports areas and new mountain communities.

Research programs designed to enhance the quality of the forest environment are essential. Harvesting techniques and patterns that are compatible or acceptable aesthetically must be developed. With additional research, we can provide texture, color, and diversity in the forest landscape, while at the same time allowing timber harvest. With a full implementation of multiple use, forest roads and trail systems can be designed to permit timber extraction as well as to provide recreation opportunity.

This annual progress report for 1972 indicates the strong research base that has been developed under the McIntire-Stennis Cooperative Forestry Research Program. The progress in individual studies reported here shows the increasing attention that the forestry schools of the Nation are directing both to problems concerning people and the environment, land use, and wood supply. We have unique opportunities, challenges, and responsibilities in discovering new knowledge and in developing the means of putting this knowledge to use. We need the continuing support the Program has earned in the Congress, the Department of Agriculture, and private industry.

Robert E. Dils
President, Association of State College
and University Forestry Research Organizations

INVENTORY AND APPRAISAL OF FOREST RESOURCES

Intelligent planning for our Nation's future prosperity depends on accurate and inclusive inventories of our renewable natural resources. Social needs and demands alter with time, and the planner must be responsive to both direct and subtle changes. Our national and world objectives remain predicated on continuing expansion and growth and the goal of a better life for people everywhere. To achieve this goal, it will be necessary to greatly improve management of our resources through improved technology. A sophisticated array of remote sensing devices spawned by the world's aerospace programs is facilitating gathering of data on the Nation's forest and range resources. Decisionmakers need such data for future planning. At the molecular and microscopic levels, continued advances in function measurements are providing information about the basic living cell and organismic levels of forest plants and animals.

APPRAISAL OF FOREST AND RANGE RESOURCES

Research Problem Area 110

Periodic appraisals of forest and range resources of the Nation are essential to determine the adequacy of public conservation policies and programs and to guide the development of private forest and range enterprises.

The timber resources of the Nation, including some 500 million acres of commercial forest land, vary greatly in productivity and availability for industrial use. They show widely divergent trends in growth, depletion, and quality. The increasing use of resource data to evaluate future needs of Federal and State forestry programs and to provide guidance for the continuing expansion of wood-using industries in various regions makes it imperative that appraisals of timber resources be intensified and kept up to date.

The range resources of the Nation vary widely in productivity, condition, and potential importance for sustaining livestock and wildlife. There is growing need for a comprehensive appraisal of range conditions and opportunities for improving capacity and use to meet future demands for livestock forage, water yield, and of wildlife habitat.

UNIVERSITY OF CALIFORNIA, CA-F*-FRU-2350-MS

Methods of estimating long-range timber supply.

H. J. VAUX

Using the concepts developed for the national timber supply model report last year and the most recent U.S. Forest Survey information, a long term timber supply model for California has been constructed. Using the target element of this model, we have completed a preliminary assessment of potential long run timber supply in the State. At 5 percent interest rate and unit elasticity of demand, a future supply of 1.6 billion cubic feet per year is obtainable at costs of production at or below the equilibrium price. To produce this supply would require intensive management of 9.4 million acres of forest land, only about two-thirds of the area currently classified as commercial forest. This target timber supply appears to be only moderately sensitive to changes in either rate of interest or elasticity of demand. Initial but incomplete studies have been made using the transition element of the long term supply model for California. They suggest that it is still possible to devise forest policies which would permit maintenance of the present statewide level of forest products harvest for the indefinite future and until current net growth in the State can be increased from the present level to that of the target described above. Analysis of economic consequences of different levels of future timber harvest in Humboldt County was continued. A statistical model for projecting future levels of employment associated with various alternative levels of timber harvest has been completed.

OKLAHOMA STATE UNIVERSITY, 1476

Simplified forest sampling based upon estimated stem distribution parameters.

N. WALKER

A total of 1,274 CFI plots from Southeastern Oklahoma were used as a population of pine-hardwood forest. Six districts, with numbers of plots varying from 141 to 224, were used as subpopulations. The frequency distributions of pine stems by 2-inch diameter classes were fitted well with the negative binomial series. Satisfactory evaluations of volume and structure were obtained by random selection of 35 percent of the sample units in each district, using the district means and the large population values for k of the negative binomial series.

The hardwood component also is adequately described by the negative binomial series. Confidence limits on sampling accuracy are being established by taking 250 random samples at each intensity. Size-class associations, strong in pine, appear to be weak in hardwoods.

Simulated sampling, applied to theoretical Poisson and negative binomial distributions, reveals the confidence intervals involved in sampling such distributions at differing intensities.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 2016-4168-022

Development of volume tables for ponderosa pine from aerial photos.

G. S. LEHMAN

UNIVERSITY OF CALIFORNIA, 2520

Mathematical simulation of forest stands.

L. C. WENSEL

CALIFORNIA STATE UNIVERSITY, 25

Total bole cubic foot volume table and bark volume relationships in old growth redwood (*Sequoia sempervirens*).

D. L. ADAMS

COLORADO STATE UNIVERSITY, 324

Classification of complex resource systems.

C. D. BONHAM

COLORADO STATE UNIVERSITY, 336

Localized environmental inventories for natural resource management planning.

W. E. FRAYER

UNIVERSITY OF MISSOURI, 167

Determination of optimum photo scale and type of film for Missouri forest conditions.

A. J. NASH

NORTH CAROLINA STATE UNIVERSITY, 4014

Estimation of parameters in nonlinear models of tree growth.

W. L. HAFLEY

NORTH CAROLINA STATE UNIVERSITY, 4038

Variability in effect of plot configuration in sampling southern pines.

W. L. HAFLEY

OREGON STATE UNIVERSITY, F-883

Regeneration survey using aerial photography and multistage, PPS sampling techniques.

D. P. PAINE and J. F. BELL

PENNSYLVANIA STATE UNIVERSITY, 2025

Structure, growth and tree mortality in mixed forest stands in Pennsylvania.

R.E. MELTON and B. J. TURNER

TEXAS - STEPHEN F. AUSTIN STATE UNIVERSITY, 1

Cubic-foot yield of old-field unthinned loblolly pine plantations.

J. D. LENHART

PUBLICATIONS

ARNEY, JAMES D., and DAVID P. PAINE

Tree and stand volumes using height accumulation and the telescopic Spiegel-Relaskop. Forest Science. Vol. 18, pp. 159-163. June 1972.

LENHART, J. D.

Predicting survival of unthinned old-field loblolly pine plantations. Journal of Forestry. Vol. 70, No. 12, pp. 754-755. 1972.

LENHART, J. D.

Cubic-foot yields for unthinned old-field loblolly pine plantations in old-field plantations in the Interior West Gulf Coastal Plain. Texas Forestry Paper No. 14. 46 pp. 1972.

REMOTE SENSING

Research Problem Area 113

Programs in agriculture and in agricultural development depend heavily on having timely information for decisionmaking. Opportunities for increasing

and sustaining the productivity of natural resources and for facilitating product flows in agriculture depend on accurate, comprehensive, and timely information on resource use, availability, productivity potential, and other characteristics. The paucity of such information is a major obstacle in the economic development of undeveloped regions of the world and a significant obstacle to the formulation of important policies and programs in the more fully developed regions.

Generally, such information on natural resources has been obtained from ground surveys. These surveys are costly and, in the more remote and inaccessible regions of the world, are difficult, if not impossible, to make.

UNIVERSITY OF MASSACHUSETTS, 13

Remote-sensing 20 years of change in the human environment in Massachusetts, 1951-1971.

W. P. MacCONNELL

Researchers and interpreters are identifying the uses of land. They are classifying the land in several categories: agricultural land, forest land, wetlands, mining and waste disposal areas, potential outdoor recreation sites, and land areas for other urban use. They are also studying the impact of urban sprawl and highway and airport construction on the landscape since 1951, when the entire land area of Massachusetts was initially classified from aerial photographs.

Maps are being prepared so that various uses of land can be measured and determination made of classifications that are increasing and decreasing in area. Data from 1951 photos reveal that only 8.6 percent of the State was in urban use and approximately 85 percent was in forests and wetlands. Although computations have not yet been made, interpreters believe that the urban use has increased 15-20 percent, up to 10 percent of the total area, since 1951.

A classification system of the uses of land has been refined and prepared for computer analyses of the individual land types. Resulting figures will serve as base data to measure human impact on the landscape in subsequent decades if similar analyses are made. They will also provide ground truth for interpretation of imagery obtained from orbiting technical satellites such as those in the ERTS and Skylab programs.

Much of the current work involves transposing land classifications to topographical maps which town conservation commissions and land planners find extremely useful in making decisions on land purchases and zoning.

ADDITIONAL PROJECTS

ALABAMA - AUBURN UNIVERSITY, 909

Standardized forest condition classes for aerial forest inventory.

E. W. JOHNSON

NORTHERN ARIZONA UNIVERSITY, ARZZ-NAU-07

Aerial surveys of land and timber resources.

T. E. AVERY

UNIVERSITY OF CALIFORNIA, 2180

Multiband spectral reconnaissance for forestry.

R. N. COLWELL

COLORADO STATE UNIVERSITY, 352

Construction of a computer-based landscape model of the Cache La Poudre (Pingree Park) watershed.

L. D. MILLER and W. D. STRIFFLER

NEW YORK - CORNELL UNIVERSITY, 147552

Resources inventory and analysis for environmental planning.

L. S. HAMILTON and E. E. HARDY

PUBLICATIONS

ANDERSON, J. R., HARDY, E. E., and J. T. ROACH

A land-use classification system for use with remote sensor data. U.S. Geological Survey Circular 671. 16 pp. 1972.

AVERY, T. E.

Trains vs. planes? Photogrammetric Engineering. Vol. 37, pp. 1284-1285, illus. 1971.

GESSAMAN, P. H., and E. E. HARDY

Mapping land use changes in the Southern Tier, 1938-68. New York's Food and Life Science Quarterly. Vol. 5, No. 3, pp. 3-6. 1972.

LACATE, D. S., and L. S. HAMILTON

Sources of information on natural resources and land use. Cornell University,
Department of Natural Resources Conservation Circular. Vol. 10, No. 1. 5 pp.
1972.

TIMBER MANAGEMENT

Urban renewal building programs coupled with unprecedented home construction and maintenance in suburbia will place ever increasing demands upon timber resources. Accelerating use of paper and related products further burgeons wood-fiber requirements. Forestry research has developed a few strains of improved trees which grow faster and better and are now available to provide adequate timber supplies for the present and for the future. Tree breeding experiments are producing rapidly growing pines and hardwoods resistant to many diseases and insect pests. Growth gains are being accumulated through intensified cultural techniques using fertilization, irrigation, and organic matter incorporation. But caution must be exercised in manipulating our delicate forest ecosystems. Thus, forestry researchers are trying to work in harmony with natural processes, so as to minimize environmental disturbance. In the long run, total costs will be reduced.

ADAPTATION TO WEATHER AND WEATHER MODIFICATION

Research Problem Area 109

The future holds many possibilities for changes in weather and climate ranging from dramatic major changes to microenvironmental ones involving plants and animals. Research in agriculture has three tasks here: (1) Characterize existing climatic patterns and propose more effective ways of adjusting to these patterns; (2) specify modifications that are clearly desirable to farm and forest; and (3) learn how modifications proposed by others will affect agriculture or natural ecology.

ADDITIONAL PROJECTS

CONNECTICUT AGRICULTURAL EXPERIMENT STATION - NEW HAVEN, 403

Mathematical simulators of the effect of environment on forests and forests on microenvironment.

P. E. WAGGONER, J. Y. PARLANGE
and N. C. TURNER

WASHINGTON STATE UNIVERSITY, 118

Modeling solar energy receipt and partitioning in mountainous topography.

D. R. SATTERLUND

PUBLICATIONS

PARLANGE, J. Y., and P. E. WAGGONER

Boundary layer resistance and temperature distribution on still and flapping leaves. Plant Physiology. Vol. 50. pp. 60-63. 1972.

WAGGONER, P. E.

Role of plants in improving the environment. Journal of Environmental Quality. Vol. 1. pp. 123-127. 1972.

BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

Research Problem Area 111

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including the Christmas tree, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the over 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

Nitrogen fertilization of loblolly pine (Pinus taeda L.)

M. C. CARTER, E. S. LYLE, JR.,
and J. W. GOODING

A total of 170 permanent plots have been established to evaluate the response of loblolly pine plantations to nitrogen fertilization. Plantation ages range from 10 to 22 years and a variety of sites and stocking levels is covered. Height and dbh of every tree on every sample plot have been recorded and upper stem diameters were determined on sample trees. Foliage samples are collected annually. Nitrogen application rates were 0, 112, 224, and 448 kg/ha in all studies. Remeasurement is scheduled after the 1973 growing season, the third growing season after fertilization.

One series of four blocks of the four treatments was selected for a study of the distribution and retention of nitrogen in the ecosystem. The plantation used was 15 years old when fertilized and averaged 13.7 m tall. Total nitrogen in the ecosystem will be estimated from samples taken in August 1971 and August 1972. Fertilizer was applied in March 1972. For each sampling, two trees of average basal area were felled on each plot for total tree analysis. Stumps were excavated (fig. 1), soil sampled to 60 cm, and litter and understory vegetation were sampled.

Analyses of the 1971 samples are nearly complete. Approximately 2,500 kg/ha of total nitrogen were found in the soil and vegetation. The percentage distribution is as follows: Pine stand - 8 percent; understory - 0.1 percent; litter - 4 percent; soil organic matter greater than 2 mm - 2 percent; and soil and organic matter less than 2 mm - 86 percent.

NORTHERN ARIZONA UNIVERSITY, ARZZ-NAU-03

Past vegetation and climates of ponderosa pine zone in northern Arizona.

D. W. BERRY

A revised date for the surface sediments of Walker Lake in north central Arizona at 2,496 m is 15,440 years BP \pm 250. A detailed analysis of pollen frequencies to a depth of 440 cm has indicated several significant climatic and vegetational changes during the period when the sediments were deposited.

The dominant Abies-Picea, as indicated by pollens found in the bottom sediments, gradually yields to Pinus up to 350 cm. At this point both Pinus and Abies-Picea give way to nonarboreal plants. At 330 cm, Abies-Picea pollens return to previous frequencies but Pinus fails to reach earlier levels although remaining strongly represented.

At 280 cm, Artemisia becomes dominant at the expense of Abies-Picea and other species. Although Abies-Picea is well represented to the 180 cm depth, at this point it yields to Gramineae, which have previously been rare. The Gramineae gradually increase to nearly 50 percent of the nonhydrophyte pollens at the surface.



Figure 1. Washing soil from excavated loblolly pine stumps to determine dryweight and nitrogen content. Northern Arizona University, ARZZ-NAU-03.

Although Artemisia is dominant from 280 cm to the surface, it begins to lose to the grasses, which increase dramatically from 40 cm upward. Modern pollen occurrence shows no significant change in the Pinus genus since 15,440 BP while the Gramineae pollen have increased from 50 percent to over 60 percent. Since 15,400 BP, Artemisia pollen have nearly disappeared as have the Abies-Picea.

The first sediments in Walker Lake were deposited near the last major maximum of the Wisconsin glacial period when precipitation was heavy and persisted through the summer. Mean temperatures were considerably lower than today. This climate was interrupted by a significant rise in temperature when sediments had reached 90 cm. Soon after this period, which probably lasted several hundred years, a brief return to a cold climate with year-long precipitation was followed by a long period with wet winters and dry summer, gradually warming to 15,440 BP.

UNIVERSITY OF ARKANSAS, 749

Establishment of forest trees in Arkansas.

H. A. HOLT

Research effort this past year has been largely directed toward developing techniques for altering vegetative communities and evaluating these treatments in terms of seedling survival and growth. Test areas have been established in old fields and extensively prepared forest sites. Methods under consideration include chemical and mechanical treatments. Mechanical treatments include shearing only, shearing and disking, and shearing and bedding. Initial results suggest that the more intensive mechanical treatments do not produce dramatically different growth results the first year. Analyses are being conducted to evaluate seedling response as related to initial size. The mechanical treatments have a relatively short term effect on vegetation regrowth and subsequent

development. Such brevity would tend to mask initial response to differences in site disturbances which may be more obvious at a later date.

Seedling response to chemical treatments, when compared with untreated seedlings, has been greater in the old field than on the intensively prepared forest site. This finding reflects the increased competitiveness of grasses compared with the abundance of annual herbaceous plants which initially invade the mechanically prepared areas. Soil moisture sampling conducted during the summer months indicates that there are consistent differences in soil moisture content with differing types of grass cover. Our tests so far indicate that, for the species examined, bermudagrass has the most dramatic influence on soil moisture at all levels sampled from 6 to 18 inches.

CALIFORNIA STATE UNIVERSITY, 18

Sowing lupine for better seedling growth and development of planted redwood and associated species.

E. W. PIERSON and D. A. THORNBURGH

Sowing of lupine seed, Lupinus albus, as a cover crop in recently logged areas of northwestern California has demonstrated that the lupine can be used as an attractive cover crop. Lupine seeds were sown on 60 test plots and broadcast sown on portions of two large clearcut blocks. The test plots represented a variety of soils, aspects and slopes. The species of lupine used in this study matures in two seasons; consequently, the green cover effect does not occur until the second year. The green, aesthetically pleasing cover crop only occurs on the area from April to midsummer of the second year. The lupine plant matures and turns brown in midsummer.

Results of the study indicate that the lupine did not significantly reduce deer browsing damage on conifer seedlings. Browsing damage was lessened while the conifer seedlings were under the shelter of the lupine; however, during the fall, winter, and spring seasons, browse was heavy on the planted conifer seedlings.

The cover crop of lupine did not significantly increase the growth or survival of planted conifers.

UNIVERSITY OF CALIFORNIA, 2179

Ecological potential of coast redwood.

E. C. STONE

Because of a unique physiological capacity, redwood (Sequoia sempervirens) can apparently serve as the vegetative component in a sewage effluent disposal system and produce a valuable crop of wood simultaneously.

The major thrust of the project has been to characterize the growth potential of redwood relative to that of the species with which it associates. These data are to be used to evaluate the efficacy of current efforts to preserve

old-growth redwoods in California and to develop a basis for commercial forest management that can take full advantage of redwood's remarkable growth capacity.

While characterizing this growth potential, we found that the roots of redwood could be deprived of oxygen (by flooding the soil) for a considerable period of time without any permanent damage. Net photosynthesis decreased slowly and although many roots died in this environment, they quickly regenerated when the soil was drained. We also found that growth was limited by an insufficiency of nutrients on the several forest soils tested.

Thus, we suggested redwood when asked to recommend a tree that could be used to dewater sewage effluent--that is, transfer water from the effluent into the atmosphere via evapo-transpiration--in a proposed central California sewage disposal system. Subsequent studies, using container-grown trees irrigated with sewage effluent, have justified this recommendation. Among the five native conifers evaluated, redwood has proved to be far superior to any of the others. Not only does it tolerate saturated soils, but when irrigated with sewage effluent, it grows much more rapidly than when irrigated with tap water (fig. 2).

Translated into expected field performance, this growth potential suggests that redwood plantations could be used to dewater sewage effluent while yielding an annual net growth return of \$200 or more per acre.

UNIVERSITY OF FLORIDA, 01534

Fertilization and nutrition of southern pine.

W. L. PRITCHETT

Forest fertilization has expanded rapidly in the Southeast, mainly because of over 200 field experiments established to study soil and biological factors affecting fertilizer use. Results from these experiments indicated widespread deficiencies in phosphorus and nitrogen for growth of young forest plantings. A significant response to fertilizers occurred in 62 percent of the experiments involving young plantings. About 50 percent of the experiments in stands 10-20 years old showed responses to nitrogen fertilizers. In several experiments, the incidence of fusiform rust was affected by fertilizer treatment. Because of the concern about this serious disease, a project was initiated to study basic problems relating host nutrition to the disease. An important breakthrough developed when the fungus was cultured for the first time on a chemically defined medium, free of its host. This advance paves the way for future investigations into factors required from the host by the pathogen, especially nutritional requirements.



Figure 2. One-year-old redwood seedlings after continuous (C) and intermittent (I) irrigation for 9 months with tap water (T) and artificial sewage effluent (E). (Scale: 1 mm = 1 cm.). University of California, 2179.

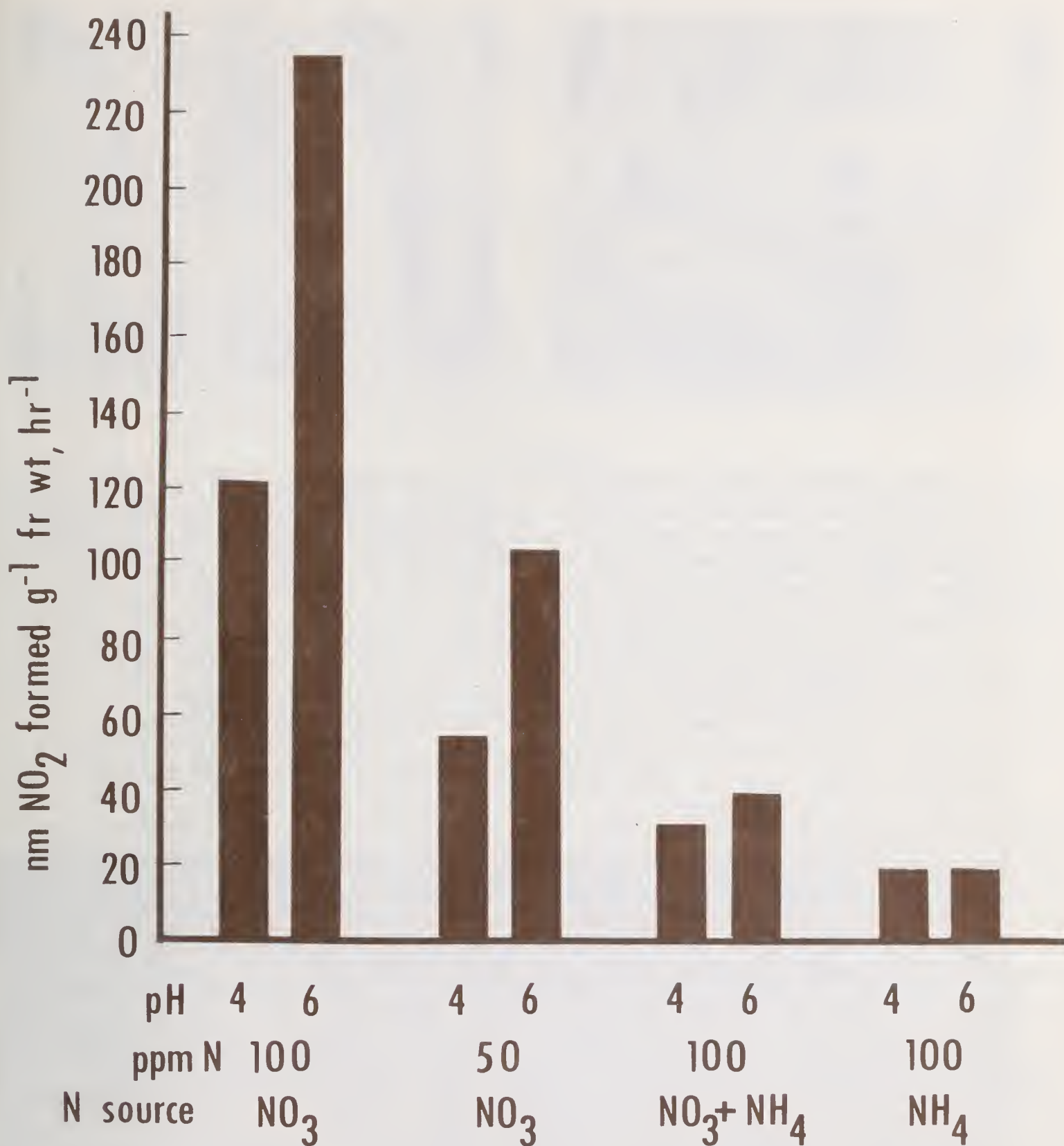


Figure 3. Nitrate reductase activity ($\text{nm} \cdot \text{g}^{-1} \cdot \text{fw} \cdot \text{t}^{-1}$) in slash pine was dependent on pH and on the nitrogen source of the substrate. University of Florida, 01534.

Other nutritional research demonstrated for the first time the presence of nitrate reductase in pine. However, this nitrate-inducible enzyme is strongly pH dependent (fig. 3). Low activity of this enzyme, important in nitrate metabolism, may partially explain why nitrate-N fertilizers are usually less desirable than ammoniacal-N materials.

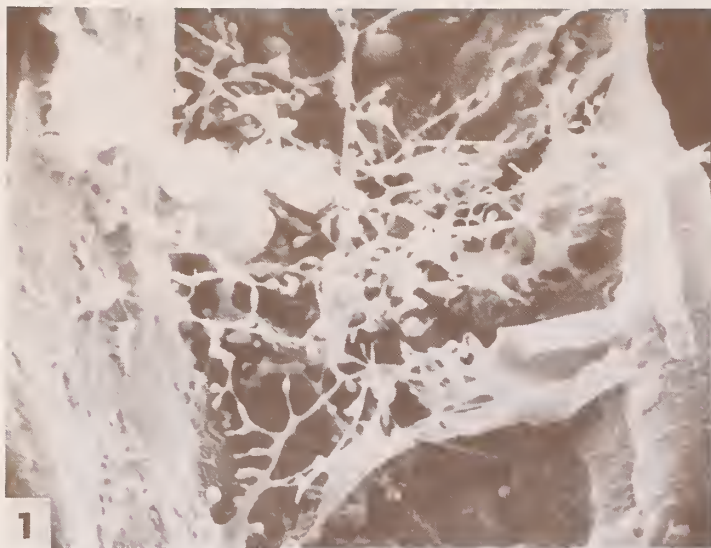


Figure 4.

View through scanning electron microscope of cytoplasmic strands within vacuole of maturing pine tracheid as it looks after freeze-fracturing and freeze-drying. X 4800. (1)

University of Georgia, GEO-0025-MS-A

View of pine tracheid in final stages of maturation following breakdown of cytoplasm. Nucleus (N) still visible in cell at right. X 1000. (2)

UNIVERSITY OF GEORGIA, GEO-0025-MS-A

Differentiation of wood fibers and growth ring formation in conifers.

C. L. BROWN

Patterns of tracheid differentiation were systematically studied beginning with dividing cells of the cambial zone and ending with autolysis of the protoplast in mature tracheids. Stem segments were prepared and viewed with transmission and scanning electron microscopy. For the latter, appropriate techniques were developed for studying the 3-dimensional organization of shortleaf pine cell protoplasts using freeze-fracturing followed by freeze-drying (Humphreys and Wodzicki, 1972; 30th Ann. Proc. Electron microscopy Soc. Amer. Los Angeles).

Observations with the scanning electron microscope revealed that the mature protoplast of the pine tracheid is composed of (1) the commonly observed peripheral layer lining the secondary cell wall, and (2) an elaborate network of cytoplasmic strands and filaments within the central vacuole (fig. 4-1). These transvacuolar strands possess numerous organelles (plastids and mitochondria) and provide an extensive surface area for rapid exchange of nutrients and metabolites with the vacuolar sap during cell wall synthesis. The breakdown of the protoplast terminates tracheid maturation and is associated with physical changes in the vacuolar membranes. The nucleus is the last cell organelle to disintegrate (fig. 4-2).

Concomitant with ultrastructural studies of differentiating tracheids, excellent growth and formation of xylem cells has been achieved in continuous liquid suspension cultures of slash pine (*P. elliotii* Englm.). Under some treatments, cultured cells can be induced to differentiate as mature xylem elements possess

varying sizes and shapes. Interestingly enough, these develop reticulate pitting, a feature common to angiosperms rather than gymnosperms. Transmission and scanning electron microscope studies are also being made on cultured cells.

UNIVERSITY OF IDAHO, 16

Forest fertilization: Its influence on stands of Douglas-fir and grand fir.

H. LOEWENSTEIN and F. H. PITKIN

To investigate the potential impact of fertilization on northern Idaho forests, 36 research sites have been established throughout the area. Growth of trees on fertilized plots will be compared with growth on (1) plots with no treatment, (2) plots which have been thinned, and (3) plots on which fertilizer has been applied in conjunction with thinning.

Fertilizer treatment was applied to 30 of the 36 experimental sites during the spring of 1972, the necessary urea being donated by fertilizer companies. The remaining six sites were selected and thinned; these will receive fertilizer applications in the spring of 1973. During the summer, six dominant trees on each site were measured for total height and their ages determined. Site index for each experimental unit and basal area for each plot were calculated. In the fall, foliage samples were collected from dominant trees on each plot and these will be analyzed for nitrogen to ascertain the magnitude of fertilizer uptake. Soil samples will also be subjected to nitrogen analysis.

In cooperation with the State of Idaho Department of Public Lands, plots were also installed on three sites (about 200 acres each in size) which received aerial applications of urea fertilizer (fig. 5). These plots will be monitored



Figure 5. The helicopter is taking off with a load of fertilizer for an aerial fertilization experiment in northern Idaho. University of Idaho, 16.

for growth response. Additionally, water samples were taken periodically from streams which run through two of these areas. These samples will be analyzed for organic, urea, ammonium, and nitrate nitrogen to detect any possible pollution effect from the fertilizer treatment.

SOUTHERN ILLINOIS UNIVERSITY, 72-R-7

Soil-site-vegetation relationships in a southern Illinois bottomland forest remnant.

G. T. WEAVER and P. A. ROBERTSON

Vegetation and soil-site factors were associated with microtopographic position in a forest located on an island within the Horseshoe Lake Wildlife refuge, Alexander County, Ill. The relatively high woody species diversity (56) is comprised of elements normally associated with upland sites in southern Illinois in addition to typical bottomland species. Overstory species on the highest sites (approximately 10 feet above mean water level of the lake), which had well-drained sandy or sandy loam soils that were free of inundation, include Fagus grandifolia, Acer saccharum, Carya cordiformis and Tilia americana, and the understory of Aesculus pavia and Asimina triloba was well-developed. In low areas where poorly drained or very poorly drained clay soils prevailed, Liquidambar styraciflua, Ulmus americana, Acer rubrum and Frazinus pennsylvanica were abundant, and the understory was poorly developed or absent. With increasing persistence of standing water, Taxodium distichum, Nyssa aquatica, Populus heterophylla and Cephalanthus occidentalis (understory) were dominant. Transitional sites, characterized by less frequent flooding and moderately light textured soils, supported Quercus falcata var. pagodaefolia, Q. michauxii, shumardii, Ulmus americana and Liquidambar styraciflua, and the understory was Asimina triloba.

Data thus far indicate (1) a wide variation in species tolerance to the various soil-site conditions, (2) soil-site vegetation relationships intricately related to depositional patterns established during the formation of the island and (3) decreasing diversity and increasing dominance as microtopographic elevation decreases, suggesting a response to environmental instability and stress.

INDIANA-PURDUE UNIVERSITY, 1476

Environmental relations of hardwood tree species.

W. R. BYRNES

Environmental studies on soil-applied herbicide distribution in black walnut and yellow poplar and on freezing injury in black walnut were conducted under controlled greenhouse and laboratory conditions in 1972.

Herbicide uptake and distribution patterns in young black walnut and yellow poplar seedlings showed that concentrations of simazine and the phytotoxic degradation product, monodealkylated simazine, were significantly higher in yellow poplar than in black walnut after treatment with equal amounts of

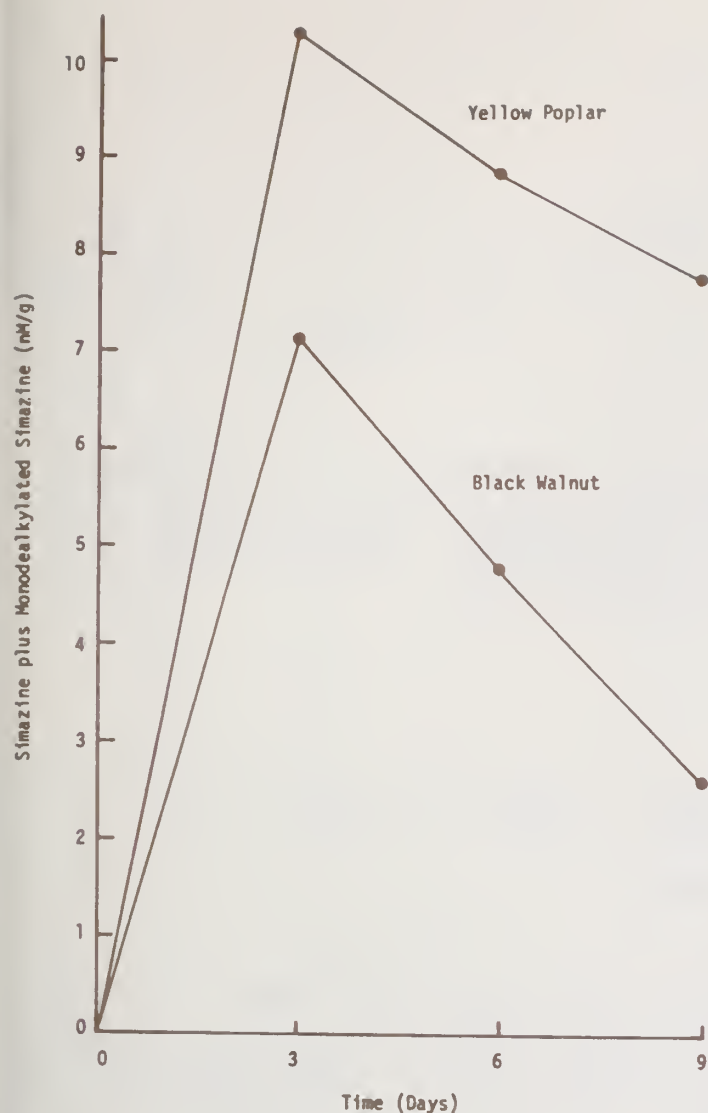


Figure 6. Concentrations of herbicides in yellow poplar and black walnut. Indiana-Purdue University, 1476.

simazine (fig. 6). Simazine uptake was greater in yellow poplar and its degradation rate faster in black walnut. Both species degraded simazine rapidly via N-dealkylation to two degradation products identified as monodealkylated simazine and 2-chloro-4,6-diamino-s-triazine. Three other simazine degradation products were isolated. Differential herbicide uptake and faster detoxification appear to contribute to the greater inherent tolerance previously reported for black walnut.

Studies on freezing injury of black walnut, which may cause stem deformation, were conducted on living bark and new shoots of 1-year-old seedlings. Stem tissue, using triphenyl tetrazolium chloride reduction and visual viability tests, was not highly susceptible to freezing injury during the normal dehardening period in late winter or spring, provided stems were not exposed to extremely rapid freezing. Newly expanded shoots subjected to slow cooling were not injured at 30° F, had minimal damage to leaf margins at 26° F, but were completely killed on 50 percent of test seedlings at 22° F.

INDIANA-PURDUE UNIVERSITY, 1477

Ordination for forest ecosystems.

C. MERRITT

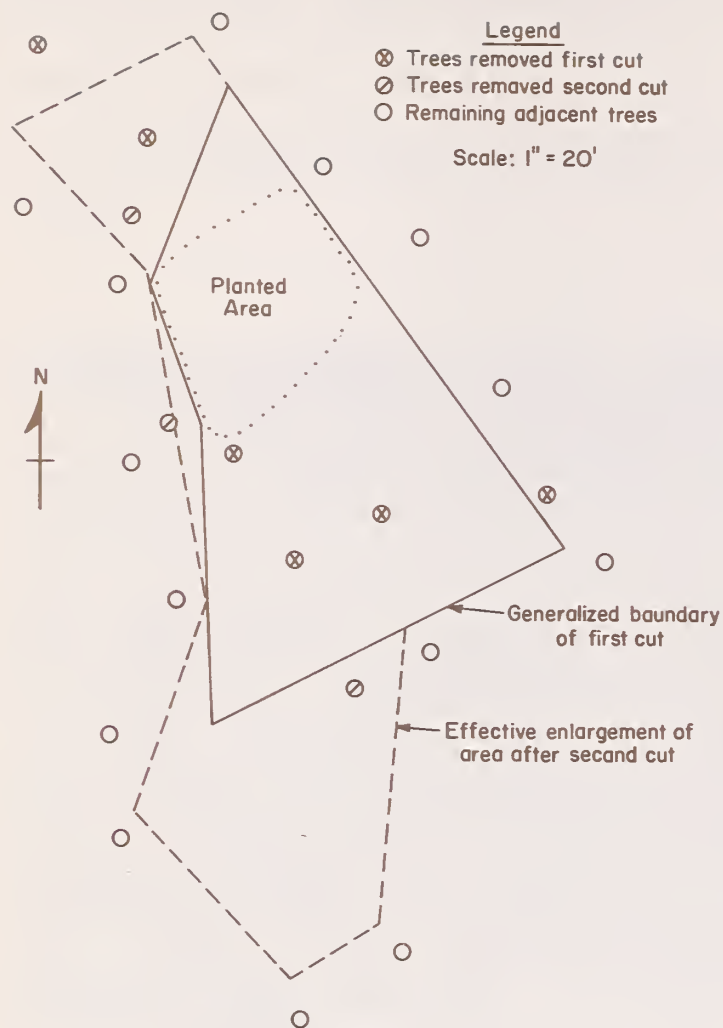


Figure 7. Anatomy of a cut in a small woodland opening, using the group-selection method. Indiana-Purdue University, 1977.

Group-selection silviculture implies periodic enlargement of cut openings to facilitate new regeneration and to increase insolation on established regeneration. Development of a computer technique to design such openings has facilitated study of this kind of management.

Figure 7 illustrates the anatomy and treatment history of a small woodland opening. It was partially planted after cutting and enlarged 7 years later. Enlargement boundaries were based primarily on the location of adjacent mature trees.

Figure 8 shows the hours of sunlight before and after a second cut at points along a N-S axis through the opening at the crown level of the planted trees. It is clear that enlargement did not significantly increase sunlight at crown level.

Continuing study is being made of the actual energy regime in these openings as related to insolation time. A literature search has been made and instrumentation assembled. Chemical light meters (anthracene in benzene) will be used for one phase of the study. Scintillation vials with foil-lined caps have been tested and shown to be superior to the usual type of vial used for such meters.

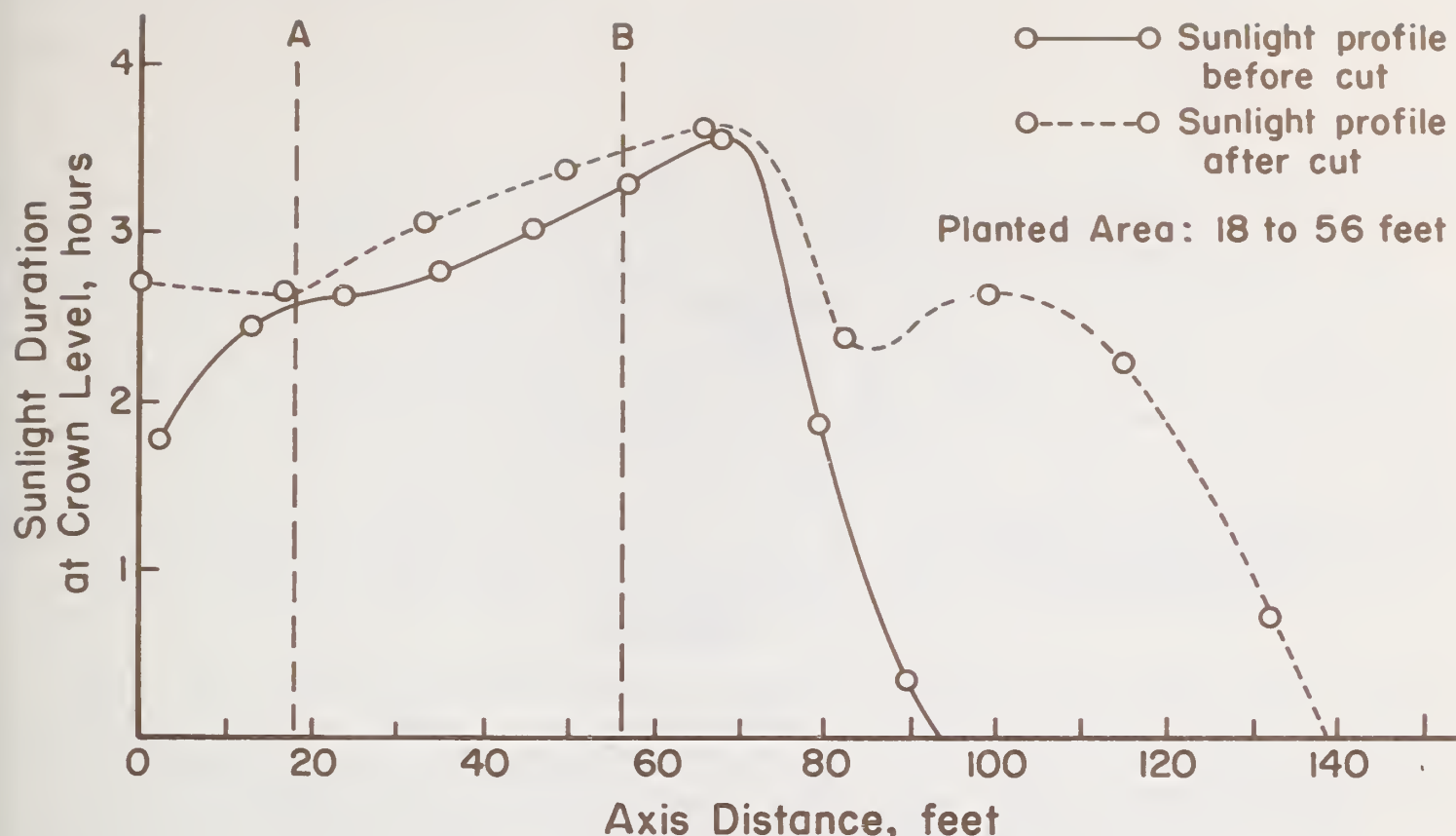


Figure 8. Profiles of sunlight duration in a woodland opening. Data represent cumulative hours of sunlight for June 21 along an N-S axis through the opening at the crown level of the planted trees. The planted portion of the area extends between points A and B. Indiana-Purdue University, 1477.

The new computer program can be used to locate cutting boundaries (fig. 9) so as to produce any desired amount of suntime within the opening. However, actual field layout of the computer-designed cut required the removal of several immature trees. The program thus not only aids the manipulation of microclimates, but it also calls attention to management decisions which must be made in group-selection silviculture.

KANSAS STATE UNIVERSITY, 770

Hardwood species and cultural practices needed for rapid fiber production.

W. A. GEYER

Short-rotation hardwood management, a concept originating in the South, is currently being investigated under plains conditions and species found in eastern Kansas.

Results from a 1966 trial planting of silver maple at spacings of 1 x 1 ft., 1.5 x 1.5 ft., and 2 x 2 ft. indicate wood fiber yields as high as those reported in Pennsylvania and Georgia. After 2 years, yields at the close

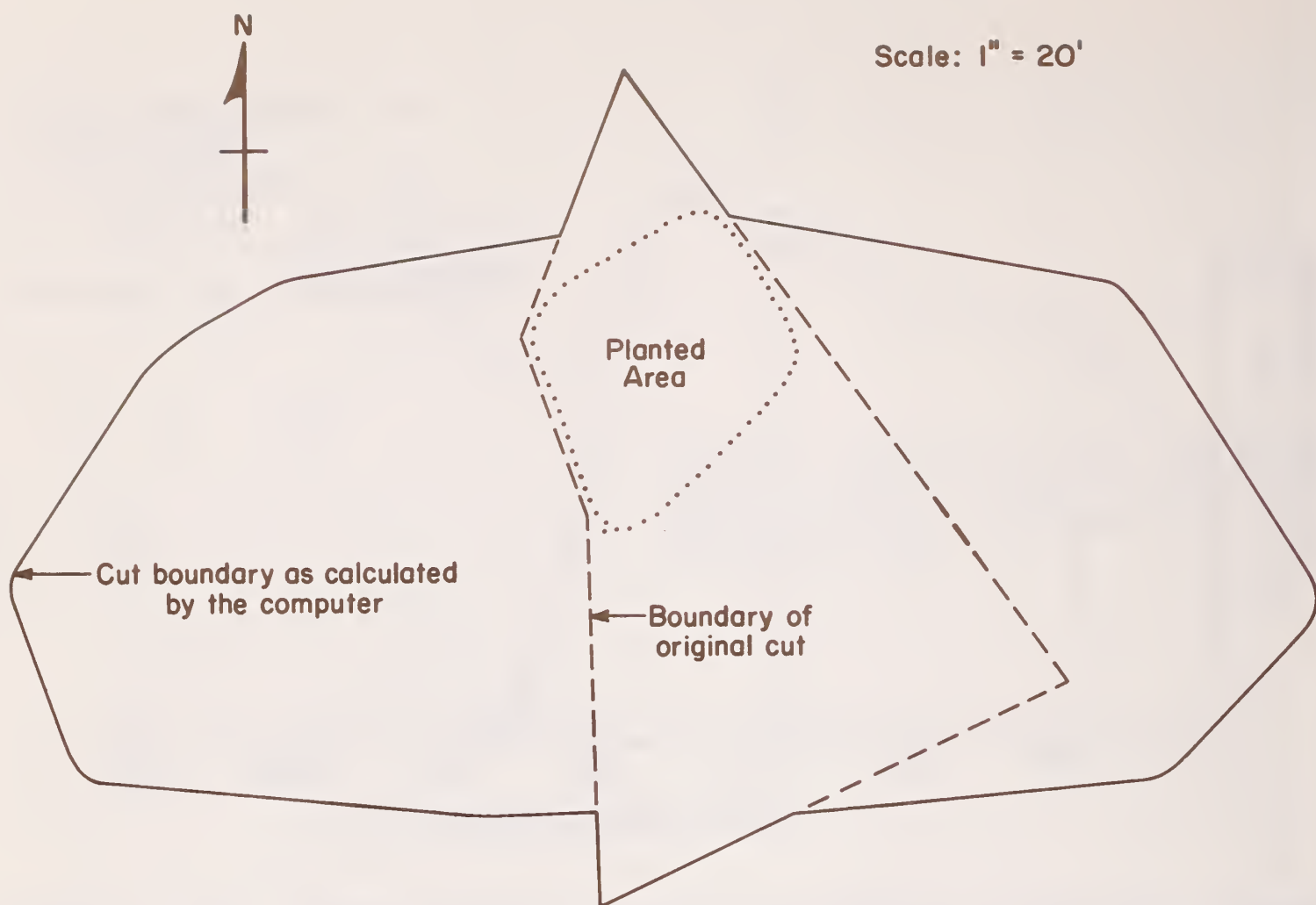


Figure 9. Cut boundary as determined by computer program. The planted trees receive a minimum of 6 hours of continuous sunlight from April 12 to September 1. Indiana-Purdue University, 1977.

spacing were three times those of the wide spacing. Biennial cuttings show little loss in production over the years; sprouting is good with slight mortality.

In 1970, tests were begun at two sites (clay loam and sandy loam soils) using one-fortieth acre plots at spacings of 1x, 2x, and 4 x 4 ft. Species tested are silver maple, eastern cottonwood, Siouxlant cottonwood, sycamore, black alder, box elder, and willow. Biennial harvests are planned.

Cottonwood and maple appear to completely utilize growing space after one season. Maple sprouts cover area after 2 months' growth. Both strains of cottonwood appear to outgrow silver maple during the first 2 years of growth. Stumps are getting larger, thus indicating machine harvest problems after two to four cuts. The specific gravity of four silver maple saplings was calculated to be 0.425 (wood and bark), which is lower than values cited for wood alone (0.53).

Competition in slash, loblolly pine plantations.

T. D. KEISTER

Results indicate that the competition index developed as a part of this project is an effective measure of individual tree competition and of the amount of release after thinning; it also appears to be an objective measure of tree dominance. Weekly dendrometer readings showed that dominant trees grew more per inch of rainfall, faster in the spring and longer in the fall, than either intermediate or suppressed trees. The ratio (R) between a tree's competition index and the number of its competing trees was used to define dominance class. Dominant trees were trees with $R \leq 0.225$, intermediate trees had $0.225 < R \leq 0.375$, and suppressed trees were those with $R > 0.375$. Cambial activity began in early March, but dominants freed by thinning and all suppressed trees responded with an initial diameter shrinkage. By October 30, each class of trees in thinned stands had surpassed the growth of their counterparts in unthinned stands.

The ratio (R) has also proved to be a means of identifying trees which have a high probability of dying. The probability of death within 5 years is 0.61 for trees with $R \leq 0.5$, but only 0.08 if $R > 0.5$. A study of the change in R with time indicates that in 4 years, loblolly pine trees with $0.4 < R \leq 0.5$ have a 0.18 probability of death, while if $0.5 < R \leq 0.6$, the death probability is 0.64. Increasing the R results from a rise in competition from neighboring trees and results in an increasing death probability.

Slash pine seemed somewhat less responsive to competition than loblolly pine.

Effects of silvicultural treatments on wood properties of even-aged loblolly pine plantations.

E. T. CHOONG and P. J. FOGG

The project has involved the collection and measurements of wood samples from trees grown in fertilization and seed-source plantations in various locations in Louisiana.

Fertilization: Based on one plantation in southeastern Louisiana, results show higher extractives-free specific gravity, longer tracheid length, reduction in fibril angle within the cell wall, and thicker latewood cell wall immediately following fertilization. However, no effect of fertilizing was found on growth rate, amount of latewood, hot-water and alcohol-benzene extractives, holocellulose, and alpha cellulose content. Samples from the pith section show considerably higher contents of some minerals than those from the outer section. Five years after fertilization, the following reductions are shown: 10 percent for ash, 20 percent for K, 16 percent for Ca, 28 percent for Mn, and 16 percent for P. Other elements (Na, Mn, Fe, and Zn) show no change. In general, the fertilizer treatments of N, P, and K show no difference in total mineral contents if both pith and outer sections are included in the analysis; however,

the Mg concentration was reduced by K fertilizer and the Fe concentration by N fertilizer. There were also interaction effects of N and K on Mg concentration, and N and P on K concentration.

Seed Source: There were significant differences in ring width and specific gravity among three plantations and five seed sources. In fiber length, there was no difference among seed sources but a significant difference between plantations in various locations.

LOUISIANA STATE UNIVERSITY, 1547

Thinning dense young loblolly pine stands with granular herbicides.

T. D. KEISTER

Results after 2 years of study of the effectiveness of a granular herbicide (picloram) for precommercial thinning dense young loblolly pine (Pinus taeda L.) stands indicate that, although mortality was greatly increased with the treatment, the degree of thinning was less than desirable from a timber production standpoint. Three treatments (10, 20, and 40 lbs/acre) were tested against a control in a dense (60,000 trees/acre) 3-year-old natural pine stand in north central Louisiana. Mortality in the treated plots ranged from 40 to 70 percent compared with about 9 percent in the control. Stocking in the treated plots remains greater than desired, and mechanical thinning at this age would be cheaper and more effective. Also the treatments caused significant losses in height growth for the survivors during the first year after treatments.

Virtually all the kill due to treatment occurred by July of the second year after treatment. Apparently there was almost no movement of the chemical into untreated areas, since mortality among trees adjacent to treated plots was no greater than that of control plots.

MISSISSIPPI STATE UNIVERSITY, 610

Nutrient cycle in loblolly pine plantations.

G. L. SWITZER and L. E. NELSON

Studies of the initial 20 years of the secondary succession leading to the oak-hickory-pine climax community were recently reported. The cycling of nutrients in the early communities of the successional sere involves many pathways and periods of duration. In attempts to categorize these pathways, Russian workers have recognized two major cycles, which they styled geochemical and biogeochemical. To these recognized cycles, we propose adding a biochemical cycle which covers the internal transfer of nutrients wholly within the biomass. This transfer or cycle represents a significant distinguishing feature in the annual nutrition of these ecosystems as the dominance of forest vegetation in the community increases. Further, our studies have demonstrated that the importance of these three cycles, in satisfying the annual nutritional requirements of the vegetative portion of the biomass, varies by nutrient (fig. 10). Also, the period of duration of nutrients within the system is specific to a nutrient and its affinity for each of the three cycles. The

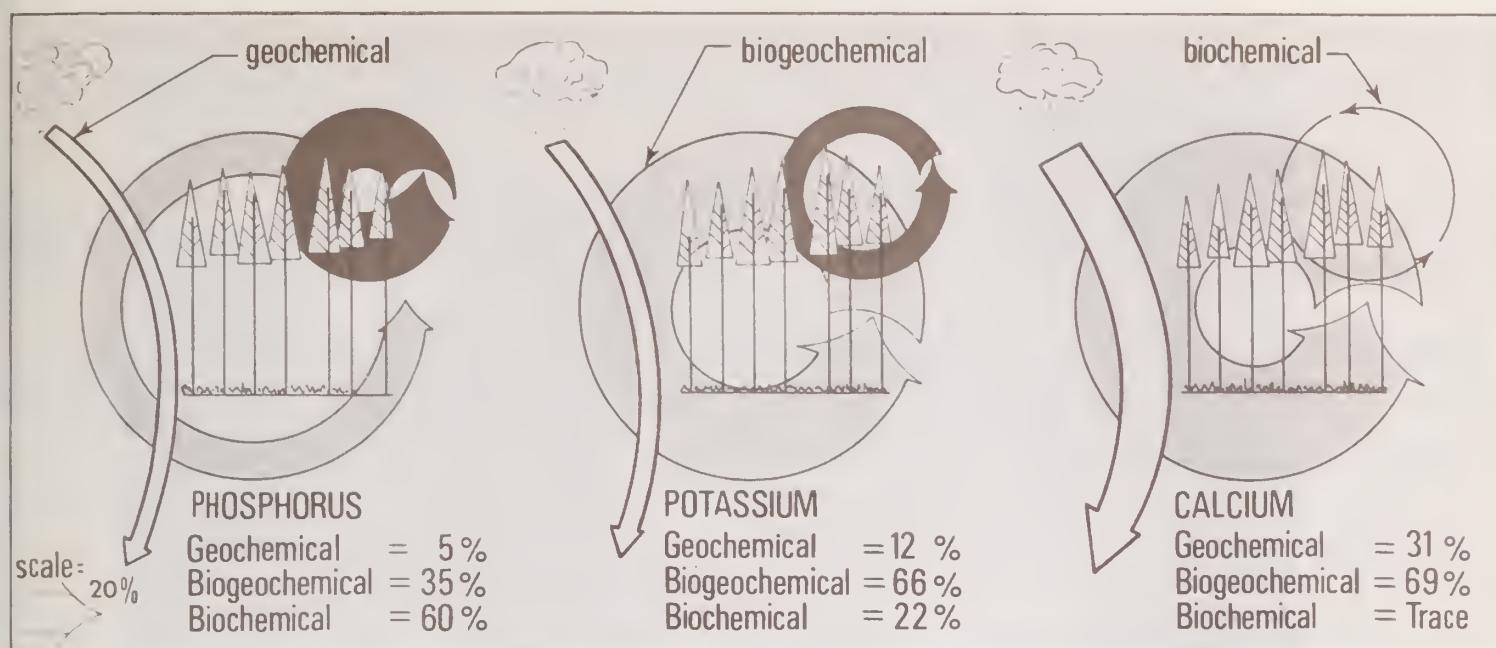


Figure 10. Researchers at Mississippi State University have quantified three cycles through which major nutrients become available to forest ecosystems. Mississippi State University, 610.

portion of each nutrient's total fund that is cycling during a given year is also nutrient specific and apparently declines as succession proceeds. For example, our data indicate that 18 percent of the K, Ca, and Mg fund is circulating in the pole stage of the pine phase of succession while only 11 percent has been reported for similar nutrients in the oak-pine community of late succession, indicating that nutrient cycles close with ecosystem development.

UNIVERSITY OF MISSOURI, 160

Certain aspects of hardwood forest ecology.

G. N. BROWN

Cold hardiness has been artificially induced in 2-month mimosa (*Albizia julibrissin* Durazz.) seedlings (to -16°C) and black locust (*Robinia pseudoacacia* L.) seedlings (to -25°C). Stem cell and chloroplast membrane systems were examined using electron microscopy, and increases in thickness and apparent protein composition appeared with increased cold hardiness.

Examination of ribosomal fractions during increased hardiness also demonstrated a concomitant rise in a chloroplast membrane fraction. Ribosomal profiles, on the other hand, did not vary significantly during induction of hardiness, supporting the observed accumulation of both soluble and insoluble (membrane) protein during hardiness. In contrast to total protein fractions, ribonuclease activity decreased during hardiness. A quantitative change in total RNA did not occur during hardiness as anticipated from decreasing ribonuclease activities, but qualitative changes were observed in specific transfer RNA's and ribosomal RNA's. All of these variations suggest sites of regulation of protein synthesis related to induction of cold hardiness.

Abscisic acid, a plant growth hormone involved in winter dormancy and possibly cold hardiness, was found to alter membrane permeability and ribosomal patterns in mimosa callus tissue cultures.

Seedlings damaged at subfreezing temperatures showed an immediate decline in xylem sap pressure while seedlings not damaged at higher subfreezing temperatures showed no drop in such pressure.

The Scholander Pressure Bomb has proven to be a rapid and convenient tool for determining degree of induced cold hardiness in mimosa and black locust seedlings

UNIVERSITY OF NEVADA, 674

Survival of grass and tree species at high elevation in the Sierra Nevada.

E. L. MILLER

Artificial regeneration trials of coniferous species on the eastern side of the Sierra Nevada have indicated that direct seeding and the planting of bare-root nursery stock are not feasible, primarily because of high rodent populations and extended summer drought. Research over the past 2 years has concentrated on the development of a regeneration system which utilizes container-grown seedlings and various cultural treatments intended to increase survival.

To date, coniferous seedlings have been reared in paper, peat, and plastic mesh containers of different diameters and lengths. Growing conditions in the greenhouse included extended photoperiod, supplemental fertilization, and controlled watering. The seedlings were grown to various ages (4-12 weeks) and outplanted in the spring in areas (fig. 11) where it has been very difficult to achieve success in revegetation.

Based on 1- and 2-year data, native species, especially Jeffrey pine, have shown the highest survival rate. Container size appears to influence seedling survival more than either container composition or diameter. For example, first-year survival of Jeffrey pine in 6- and 9-inch plastic mesh tubes was 30 and 70 percent respectively. Paper containers have been highly susceptible to rodent damage immediately after outplanting. Results from additional trials show a 50 percent greater survival rate for seedlings planted under the influence of shade compared with those planted on exposed sites.

NEW MEXICO STATE UNIVERSITY, 5

Soil-site requirements for ponderosa pine.

A. G. WOLLUM

Three studies were conducted under this project. The first study delineated six major forest types, representing a moisture gradient, within which forest floors were sampled. Forest floor dry weights increased from 9 to 81 metric tons/ha directly as the moisture gradient increased. Nutrient concentrations



Figure 11. Planting site at high elevation on the eastern rim of the Lake Tahoe basin. University of Nevada, 674.

were not related to the moisture gradient, except for potassium. However, total nutrients were greatest in the more mesic stands.

The third study evaluated the use of "tubelings" as a new approach to forest regeneration in the Southwest. Results indicate that seedling survival in the Conwed mesh tube was better than in the split polystyrene Ontario tube. The two rooting media used (Peat and silva fiber) appeared to perform similarly for the support of plant growth. Of the containerized seedlings, planted on sites that had been conventionally prepared, 98 percent failed to survive. However, seedlings planted under an oak or an aspen nurse crop had a 70 percent survival 9 months and 50 percent survival 12 months after outplanting. There was no significant difference between survival of seedlings outplanted under the oak or aspen. Both Douglas-fir and ponderosa pine appear to be adaptable to containerized planting.

NEW YORK, STATE UNIVERSITY OF NEW YORK, 111-4-7

Effects of different timber harvesting treatments and ameliorative measures.

W. J. GABRIEL and R. L. MARLER

An interdisciplinary team is evaluating four timber harvesting treatments, plus post-logging measures designed to ameliorate undesirable side effects on the forest environment. Treatments include: (1) individual tree selection with no control over logging practice; (2) individual tree selection with skid trail layout, directional felling, top lopping, and skid trail rehabilitation

imposed; (3) patch clearcutting with skid trail layout, directional felling, top lopping, and skid trail rehabilitation imposed; and (4) strip clearcutting with directional felling, top lopping, and skid trail rehabilitation imposed.

The study evaluates effects upon residual stands, soil, small mammals, and birds. Comparative costs of different treatments are being determined, and reaction of lay persons to the cutting treatments is being evaluated. Collectively, these provide a comprehensive overview of the treatments and the relative advantages and disadvantages of each.

To date, treatments have been made at two different logging sites. Work has been laid out at a third location for cutting in fall 1973. Production data were obtained during logging. Post-logging effects will be evaluated in summer 1973 on sites already logged, and after logging at the third site.

Results from the study should assist landowners in weighing alternatives for timber harvesting on their lands and in identifying possibilities for alleviating side effects considered undesirable by some people.

NORTH CAROLINA STATE UNIVERSITY, 4018

Fertilization and irrigation of seed orchards.

C. B. DAVEY

This project was concluded in the last four of seven seed orchards involved. Positive trends in seed production in response to N and P fertilization and proper irrigation, reported previously, continued. Height and diameter measurements in one orchard which had been fertilized and irrigated for 7 years showed no increase in height attributable to treatment but a large increase in diameter. These results substantiate the hypothesis that tree height growth is under strong genetic control while diameter growth is primarily attributable to environment. At the same time, the cone production per tree was almost tripled by fertilization plus irrigation and the number of nonproductive clones was cut in half. Nitrogen and sugar contents of 1-year-old twigs and needles of eastern white pine were determined and related to fertilization and strobilus production. Total N increased 35 percent and soluble N 95 percent in response to heavy N fertilization. At the same time, total sugars increased slightly and reducing sugars remained unchanged. Correlations between N fractions and strobilus production were weakly positive. Results obtained in this project now serve as the basis for operational soil management on approximately 3,000 acres of seed orchards throughout the Southeast.

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 5

Reproduction of red oak and yellow poplar.

A. R. VOGT

Physiological research has been conducted to investigate seed stratification and pollen tube development of northern red oak (Quercus rubra L.). The effects of soaking and cutting acorns on germination of unstratified red oak and



Figure 12. Germination of unstratified northern red oak. After the pericarps were removed, the basal one-third of the cotyledons was excised. Twenty seeds were soaked in gibberellic acid for 0, 17, or 40 hours (left to right in photograph) at 4 mm. Hg vacuum. Untreated controls did not generate. Ohio Agricultural Research and Development Center, 5.

evaluations of changes in levels of phenols and growth hormones with stratification were determined. Results suggest that stratification of red oak depends on a series of physiological events, including an accumulation of polyphenols, a breakdown of a nonphenolic inhibitor and the presence of a gibberellin-like promoter. Treatments bringing about these conditions replaced chilling requirements (fig. 12). Diffusates from red oak flowers were obtained periodically during the first 2 weeks following pollination. The influence of the substances on pollen tube growth in vitro was determined. A pollen promoter was present initially, followed by the preponderance of a pollen tube inhibitor by the second week after pollination. The biochemical nature of this system has not yet been characterized. A cooperative study on seed development of yellow-poplar (Liriodendron tulipifera L.) with the State Nursery at Marietta, Oh has been initiated.

An environmental and physiological response model of Douglas-fir growth.

R. H. WARING

Geneticists have conducted extensive tree improvement studies to determine the effect of geographical seed source on growth and survival of Douglas-fir. Results thus far indicate seed source is an important factor in raising better seedlings for expanding reforestation programs in the United States. Although differences in growth and survival have been correlated with geographical seed sources in broad terms, it is not yet possible to predict how well genetic stock from a specific environment will perform when moved to a new environment.

A study is in progress in western Oregon to evaluate four genetic plantations to determine the growth responses at each site in relation to environmental factors of temperature, light, and moisture. Also being developed are predictive models to relate seasonal growth patterns to field environments and genetically linked responses.

Data collected thus far have enabled construction of a mathematical model that permits prediction of a transpiration index closely correlated with stomatal control and photosynthesis. Indications are that transpiration is not only controlled by the humidity of the air, but by the plant itself. If temperatures are cold or freezing, the pores in the leaves are partially closed. The possibility that races of Douglas-fir differ in their ability to control water loss was tested. No differences were found in established trees, leaving two possibilities for the observed difference in height growth: (1) differences in photosynthetic efficiency, and (2) differences in ability to establish root systems. Continuing efforts are directed to an investigation of both alternatives.

SOUTH CAROLINA-CLEMSON UNIVERSITY, 706

Timing harvest in even-aged timber stands.

J. R. WARNER

A practical method for timing the harvest of even-aged timber stands to maximize the owner's investment returns is the objective of this project. The approach is to forecast net stand value growth for a 5-year period and compare this with estimated best alternative returns open to the owner for investment of the stands' present harvest value. This method generally is the classical concept of financial maturity.

Clemson Forest records have been modified to incorporate this analysis. A management record is kept on each stand in the forest; information on pertinent and necessary variables is entered on this record. An inventory, made by point sample, provides the present stand volumes and values as the base for inventory projection. The sample consists of at least three points that may be taken with a 5, 10, or 20 factor prism. The resulting stock and stand tables are displayed by 2-inch d.b.h. classes and each entry is qualified by its standard error.

Regression equations, that project individual tree growth for a period of 5 years, use both stand and individual tree variables. Tree volumes and values are expanded to per acre volumes and values and compared with the best alternative opportunity for investment of initial growing stock value. The process readily separates fractional portions of forest growing stock ready for removal and evaluates stand growth rates based on leaving or removing the financially mature portion. This analysis procedure is operational on the Clemson Forest for stands of yellow poplar, shortleaf, Virginia and loblolly pines.

SOUTH CAROLINA-CLEMSON UNIVERSITY, 789

Irrigation and fertilization on upland forest.

N. B. GOEBEL

This study was established in 1968 to determine the relative importance of (a) moisture stress and (b) mineral nutrient deficiency in restricting growth on an upland mixed hardwood-pine stand. During 1968-72, 9 to 18 inches of irrigation were required to maintain a net water balance. A complete fertilizer (NPK) was applied in 1971 at the rate of 300 pounds per acre in a 2:1:1 ratio. Annual measurements of diameter growth of five oak species and shortleaf pine were taken to determine response to treatments. Growth data were also obtained from increment cores for three pre-treatment years.

Significant responses in diameter growth among the pre-treatment years were exhibited in favor of 1967 and for scarlet oak among the species. For the irrigation period, 1968-70, the additional water provided caused no significant growth response over that obtained with normal rainfall. However, the response of scarlet oak, particularly in 1968, again showed a significant difference over the other species. Results of fertilization indicated that growth response was significantly better for all species in 1972 than for nonfertilized trees. Scarlet oak showed the best growth during the entire study.

Changes of frequency and occurrence of herbaceous vegetation, understory woody vegetation, and seedling establishment are being evaluated. Results indicate that irrigation did not produce additional diameter growth. Although fertilization produced additional growth, present stand conditions, including overstocking, trees of poor form, and low vigor, tend to offset such benefits.

SOUTH DAKOTA STATE UNIVERSITY, 556

Visual documentation of successional changes of the Black Hills pine forest.

D. R. PROGULSKE

In 1874, General George A. Custer's expedition to the Black Hills included pioneer photographer William Illingworth, whose commission was to provide a photographic record of the expedition. In 1971-72, a South Dakota State University professor, Donald R. Progulske, returned to as many of the original Illingworth sites as could be located. Of the 65 Illingworth views, exact photostations of 30 were relocated and rephotographed. These matching photographs provide a graphic documentation of the successional changes that



Figure 13. Ponderosa pine has extended new growth (top photograph) into formerly open areas (bottom photograph). South Dakota State University, 556.

have taken place in the Black Hills pine forest over the past 100 years. As illustrated (fig. 13), ponderosa pine has extended new growth into formerly open areas now that the influence of fire has been removed or seriously curtailed. Unless controlled by removal of some trees through management or natural causes, the pine may develop into stunted, overcrowded stands. This development depletes natural water sources, crowds out forbs and grasses necessary for wildlife and livestock production, and inhibits tree growth so that trees do not reach sawlog size. The photographic comparison provides a unique record of the ecological changes wrought by man in the Black Hills.

TEXAS A&M UNIVERSITY, 1673

Intensive culture of hardwoods.

R. G. MERRIFIELD

Six clones of eastern cottonwood were grown in sand culture and irrigated with a solution containing four levels of N, P, and K plus a complete solution of other required nutrients. After 130 days, maximum dry matter production for all clones occurred at 50 ppm N, 25 ppm P, and 50 ppm K. These yields were not significantly greater than those measured at 10 ppm N, 5 ppm P, and 10 ppm K. A sharp reduction in dry matter production occurred at 300 ppm N, 150 ppm P, and 400 ppm K. Visual symptoms of phytotoxicity were clearly evident at this nutrient level (fig. 14).



Figure 14. The high concentration (D) of nutrients in the sand culture resulted in burned leaf margins. Texas A&M University, 1673.

Clonal response to nutrient levels varied as much as 64 percent. Two clones were quite tolerant of the highest nutrient levels, while another produced the greatest yield of all clones at the lowest treatment level. The strong clone x nutrient interaction suggests that there is considerable potential for selection of clones for fertilization response.

Chemical analyses showed concentrations of N, P, and K in the leaves increased with increasing nutrient levels. The foliar concentration of Mg and Ca were negatively correlated with nutrient levels. Terminal foliage contained greater amounts of N, P, and K and lesser amounts of Mg and Ca than basal foliage.

Foliage samples were collected from the same clones growing in a field fertilization study and from trees growing in an adjacent natural stand. Nutrient content of foliage in the field was comparable to that found at the lowest level of nutrient treatment in the sand culture.

Nutrient requirements of eastern cottonwood are quite modest. There appears to be some potential for fertilization through the screening of promising clones.

VIRGINIA POLYTECHNIC INSTITUTE, 636125

Synthesis of ribonucleic acid and development of the ribosomal system.

R. E. ADAMS and L. B. BARNETT

Synthesis of proteins and nucleic acids precedes seed germination. This investigation was concerned with nucleic acid metabolism and development of polyribosomes in female gametophytes from dormant and nondormant seeds of sugar pine, and it determined changes in these processes as dormancy is broken and germination is initiated.

Monoribosomes were present in dry female gametophytes and polyribosomes developed during the first 36 hours of stratification. Evidence indicated this development used messenger RNA present in the dry seed. Ribosomes and polyribosome were synthesized throughout the 10 days of germination although by that time female gametophytes had lost 61 percent of their dry weight and were visibly senescent. The ribosomes had a sedimentation coefficient of 78.2S and contained 41 percent RNA and 58 percent protein. Three ribosomal RNA components were present with different base compositions and sedimentation coefficients of 28S, 18S, and 5S.

DNA, total RNA, and RNA in subcellular fractions of female gametophytes did not vary during stratification. Total RNA rose during the initial 40 hours of germination, primarily because of increased ribosomal RNA. Stratification increased capacity of female gametophytes to synthesize RNA. During germination RNA synthesis rose during the first 3 days, subsequently declined through the

7th day, and increased again during the 10th. Finally, an in vitro, cell-free, poly-U dependent, amino-acid incorporating system was prepared from embryos and characterized.

UNIVERSITY OF WISCONSIN, 1675

Quantification and simulation of forest growth.

A. R. EK

A generalized computer model, program FOREST, has been developed to simulate the growth of mixed-species even- or uneven-aged forest stands. Recently the program was expanded to include capabilities for simulating forest reproduction. The model now considers seed production, seed dispersal, germination, competition and mortality, plus stocking and site manipulation by man. Input for the model is a set of real or generated tree locations and associated tree characteristics. Each tree is grown for a number of projection periods based on potential growth functions which are modified by competition measures. The latter are based on relative tree size, crowding, and shade tolerance. Mortality is obtained when trees fall below specified minimum growth rates. Reproduction is generated by the seed and sprout production of the overstory. Numerous site alteration or cutting options may also be specified for implementation as the stand develops over time. Output of the model is in the form of periodic stand tables containing yield and mortality for numerous products including board feet and biomass.

The model involves a logical step-by-step formulation of reproduction, growth and competition processes. The result is that simulation of forest growth and dynamics can be achieved with a minimum number of critical parameters and a relatively small amount of calibration data. FOREST was designed specifically to serve as a management tool for evaluating the response of stands to treatment. It should also serve as a basic framework to be refined as biological research advances. Field data have been collected to facilitate adaptation of the model to several important forest types in Wisconsin. The model will then serve as a major tool for evaluating silvicultural alternatives.

UNIVERSITY OF WYOMING, 880

Biotic communities of forests and grazing lands.

H. G. FISSER and L. I. PAINTER

Areas dominated by thick stands of scrubby juniper trees (Utah juniper - Juniperus osteosperma and Rockymountain juniper - J. scopulorum) in Wyoming offer potential for improved wildlife habitat following removal of these species and revegetation with more desirable plant species. Seeding trials in the juniper zone in the Big Horn Basin were conducted to determine preferred season for seeding, preferred juniper control treatments, preferred methods of planting, and preferred species for reseeding.

The three study sites were selected to represent the lowest elevation and most arid portion of the juniper zone, a mid-elevation site, and a site at the upper

elevation and most mesic location within the juniper type. Exclosures were constructed and the enclosed juniper was treated by spraying, bulldozing, and burning.

Evaluation 2 years after treatment showed that seed planted outperformed seed that was broadcast, and that fall seeding applications were superior to spring applications for most species. Burned and bulldozed treatment areas were superior to sprayed treatment areas in seedling production. Continued toxicity of picloram chemical greatly reduced establishment of most species. Seedling numbers were extremely low due to severe competition from weedy annuals, low rainfall, and utilization of the seedlings by small mammals. Species observed to be best adapted to study sites were Astragalus cicer, Artemisia cana, A. nova, A. tridentata, Amelanchier alnifolia, Cowania mexicana, Medicago sativa, and Penstemon palmeri.

Evaluation the third year after treatment indicated that more seedlings survived on the sprayed treatment areas within the exclosures than on the burned treatment areas. High competition from numerous fast-growing weedy plants coupled with low moisture and high summer temperatures tended to make the burned treatment areas poorer sites for seedling establishment.

ADDITIONAL PROJECTS

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Ponderosa pine stand density measures.

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K. S. WALTER

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Site relationships and productivity of foothill woodland-shrub grazing lands in Idaho.

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H. LOEWENSTEIN

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Effects of selected cover crops on the establishment of seedling black walnut.

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Growth analysis of Pinus strobus related to provenance.

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SOUTHERN ILLINOIS UNIVERSITY, 72-R-24

A study of the first year performance of six seed sources of black walnut (*Juglans nigra* L.) grown in wind-exposed vs. protected environments.

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GENETICS AND BREEDING OF FOREST TREES

Research Problem Area 301

Forest practice today is based largely on wild forest trees. Unlike crop plants, trees have not undergone centuries of controlled selection and breeding to make them more useful to man. There is strong evidence that through application of genetic principles, we can produce tree varieties that grow faster, resist most major destructive pests, have specified wood properties, or yield more sap or gum. It should be feasible to develop straighter form, fewer limbs, and resistance to climatic extremes. Quality and yield of timber-related crops, such as naval stores, ample sap, and Christmas trees, can be improved through application of research findings.

Crossability and compatibility patterns in spruce.

G. H. FECHNER

Ovule development was studied in reciprocal crosses between blue spruce and Englemann spruce. After successful pollination, reproductive failure was found to occur at several points through the proembryo stage. The success of the pollen varied from nongeneration to slight penetration of the nucellus before death occurred because of archegonial penetration and fertilization.

Cessation of hybrid ovule growth occurred at different stages from the free nuclear stage through the egg stage. Irregularities within the archegonium before degeneration included the presence of large bodies, additional scattered chromatin-like material, and extra nuclei. Female gametophytes without archegonia characteristically contained proliferated and necrotic cells in the archegonial region. Necrosis of the female gametophyte occurred 9 days after strobilus pollination in unpollinated ovules. Englemann spruce crossed with blue spruce ovules were similar to the reciprocal cross except when (1) the female gametophyte developed into a group of few but very large cells and (2) greatly shrunken nucellar tissue was found in ovules with cellular female gametophytes.

Incompatibility rather than embryo inviability is apparently the primary mechanism preventing high crossability between these two spruce species.

In another aspect of the work, cones of eight blue spruce trees at two locations in Colorado were collected biweekly from approximately 1 month after initial female receptivity until natural seed shedding occurred. Extracted seeds were germinated in petri dishes at the time of collection, and microscope slides were prepared of developing ovules on the same collection dates.

Full-seed germination reached its significant peak, and germination speed its significant minimum 6 weeks prior to natural seed release for the trees at 5,000 feet (fig. 15) and 4 weeks prior to natural seed release for the trees at 7,600 to 8,500 feet. In both instances, these peaks were reached about 75 to 80 days after initial female receptivity. A differentiated embryo, though not a fully developed one, was necessary in the ovule for germination to proceed.

SOUTHERN ILLINOIS UNIVERSITY, 70-R-21

Effects of soil temperature on growth of black walnut seedlings under greenhouse conditions.

J. S. FRALISH

The goal of this study is to determine if there is a latitudinal and/or longitudinal gradient in the response of walnut seedlings to soil temperature regimes. The presence of such a characteristic would indicate that seed sources could be selected to fit specific environmental situations to gain maximum growth.

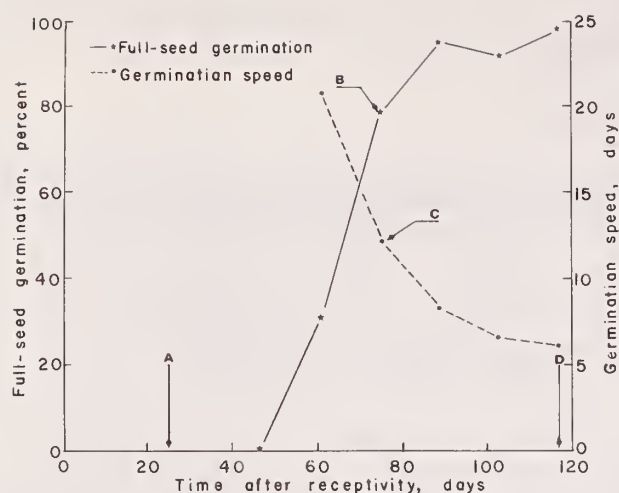


Figure 15. The relationship of the germination of blue spruce seed that has occurred to date since female receptivity. A = 50 percent of cones pendent; B = Maximum significant germination; C = Speed of minimum significant germination; and D = Natural release of seed. Colorado State University, 319.

Black walnut seed is being collected from three parent trees at each of five different sites along each of three longitudinal lines. After germination, the seedlings are studied under five different soil temperature regimes (7°, 14°, 21°, 28°, and 35° C.).

The apparatus for controlling soil temperature consists of plastic tubing coiled inside of 6" x 24" pots filled with a special soil mixture. Water of specified temperature is pumped through the tubing from a reservoir. Reservoir temperatures are controlled by immersion heaters and refrigerator units controlled by regulators.

Seedlings from sources along a longitudinal line through Illinois and Mississippi were grown through the summer and are being measured for root and shoot length and dry weight this fall.

IOWA STATE UNIVERSITY, 1872

A physiological analysis of wood fiber yield.

J. C. GORDON and D. I. DICKMANN

Work is concentrated in three major areas: (1) studies of the effects of genotype and environment on growth rate in selected Populus clones, with particular emphasis on identification of physiological and phenological criteria to use in selecting clones for rapid growth and high yield; (2) the effects of growth acceleration on wood anatomy and properties; and (3) mathematical modeling of tree and stand growth under intensive cultural conditions. Studies completed this year, or nearing completion, have (1) identified optimum soil moisture and air temperature conditions for the growth of a hybrid poplar, (2) quantified the response to nitrogen for two Populus clones important in intensive culture field trials, (3) shown that these two clones differ markedly in their nitrate reductase response to artificially applied nitrogen, (4) developed a rapid method of screening large numbers of clones for CO₂ compensation point, a potential indicator of photosynthetic efficiency, (5) demonstrated that high levels of artificially applied nitrogen have little

effect on fiber percentage or fiber length in 1-year-old material of two Populus clones, (6) shown that peroxidase activity and expression vary with genotype and environmental treatment in Populus clones and aspen callus cultures, and (7) allowed the development of mathematical models of individual tree and stand growth for young stands under intensive culture.

In this project we maintain close cooperation with researchers on the Maximum Fiber Yield project of the North Central Forest Experiment Station and receive financial support from the station. The studies of peroxidase and aspen callus culture were done in cooperation with the U.S. Forest Products Laboratory.

UNIVERSITY OF MINNESOTA, 19-78

Hybridization in Populus.

C. A. MOHN

The objectives are to produce and/or test intra- and inter-specific hybrids of Populus under Minnesota conditions and to relate genetic variation in natural populations to the results of hybridization. From 1965 to 1971, efforts were concentrated on interspecific hybridization within the section Leuce. Many of the vigorous hybrids now in tests had local P. tremuloides as the female parent and southern European sources of P. tremula as the male parent. Hybrids between local P. tremuloides and P. grandidentata also show promise. At present most materials have not reached an age or size which will permit positive evaluation. Current work with aspens includes: (1) continuing the creation and evaluation of promising combinations, (2) establishment of F_2 and backcross studies, (3) carrying out inbreeding studies using bisexual, full-sib and half-sib materials, and (4) establishing small clonal tests over a range of sites to evaluate genotype-site interactions.

In 1972 large-scale crossing of P. deltoides was initiated. A series of inter- and intra-provenance crosses were completed. Two females and three to four tree pollen mixes from each of five provenances were used. The five provenances (Minn., Mo., Neb., Ohio, and Ill.) were selected on the basis of their performance in existing field tests. In addition a series of 100 biparental crosses between and within Minnesota and Missouri sources were completed. These materials are being evaluated in greenhouse tests with field testing to follow. Height growth after 5 months in the greenhouse suggests that interprovenance hybridization may be a valuable source of rapid-growing materials.

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 9

Selection and breeding of forest trees.

D. B. HOUSTON

The eastern spruce gall aphid (Adelges abietis L.) is one of the most important pests of Picea abies and P. glauca nursery and Christmas tree stock. In a continuing study of resistance in these species, an eight-tree diallel cross was completed in P. glauca and another initiated in P. abies; all phenotypic

mating combinations (galled x galled, galled x gall-free, gall-free x gall-free) were employed. In 1973-74, 3,000-4,000 full-sib progeny will be available for resistance testing in both species. Thin-layer chromatographic and spectrophotometric analyses of phenolic compounds in the foliage of both species revealed well-defined chemical markers for resistance and susceptibility. Half-sib and stand seed collections from one-third of 18 selected Quercus rubra stands were accomplished in the State-OARDC cooperative improvement program for native hardwood species. Collections will form the basis for progeny test evaluations of single-tree versus stand selection techniques, with eventual conversion of the plantations to seed orchards. Height growth and resistance to Melampsora leaf rust and Fusarium canker were evaluated in two test plantations of 20 selected Populus deltoides clones established in 1970-71. Final replacement plantings were accomplished in fall 1972.

SOUTH CAROLINA-CLEMSON UNIVERSITY, 717

Variation and tree improvement studies in the genus Quercus.

R. E. SCHOENIKE

Plantings of a seed source study of Quercus falcata (Southern red oak) were made in January 1968 and January 1969 on a cutover upland oak-hickory site on the Clemson Forest. The 1968 plantation contains 21 sources, each represented by one to five parent trees. The 1969 plantation contains 39 sources, each represented by one to eight parent trees. Maintenance since planting has consisted of annual cleanings and plot and tree identity markings. Measurements were made in March 1972. Mean source survival in the 1968 planting was 66 percent, ranging from 76 percent (Oregon Co., Mo.) to 46 percent (Lincoln Par., La.). Mean plantation height was 2.5 ft., ranging from 3.6 ft. (Colleton Co., S.C.) to 2.0 ft. (Clarke Co., Ga. and Southampton Co., Va.). Mean source survival in the 1969 planting was 63 percent, ranging from 89 percent (Nash Co., N.C.) to 42 percent (Alachua Co., Fla.). Mean plantation height was 1.7 ft., ranging from 2.8 ft. (Colleton Co., S.C.) to 1.2 ft. (McCurtain Co., Okla.). In general, all South Carolina (local) sources are showing superior height at ages 4 and 5 years, although their survival is no more than average. The Florida sources are inferior in survival and the northern and far western sources are inferior in early height growth. No conspicuous diseases or insect pests have been noted thus far.

TEXAS-STEPHEN F. AUSTIN STATE UNIVERSITY, 12

Estimating the frequency of natural loblolly X shortleaf pine hybrids in east Texas.

R. R. HICKS, JR.

Natural hybridization with shortleaf pine (Pinus echinata Mill.) has been assumed to be responsible for fusiform rust (Cronartium fusiforme, Hedge and Hunt) resistance of western provenances of loblolly pine (Pinus taeda L.). If introgression has occurred in eastern Texas, natural backcrossing should have produced optimum genotypes which incorporate rust resistance of shortleaf with

rapid growth of loblolly pines. In a pollen phenology study, two species were found capable of natural crossing since an overlap in pollen shed existed.

Needle, cone, and bud characteristics were used to classify trees in loblolly, shortleaf, or hybrid pine groups. Diagnostic morphological traits were selected based on within-tree sampling efficiency and the existence of a recognizable difference between the two species for the traits.

The frequency of natural hybrids was determined from a sample of 164 trees in 16 natural pine stands in an approximate 60-mile radius of Nacogdoches, Tex. The morphological data were examined by hybrid index, cluster analysis and factor analysis techniques. The proportion of natural hybrids, including backcrosses, was determined as approximately 35 percent of the overall population.

Half-sib seedlings from parents classed as natural hybrids were intermediate to seedlings from either parent species for several morphological traits and possessed some characteristics typical of both parental species. Statistical examination of the seedling data indicated significant differences among the three parental groups.

ADDITIONAL PROJECTS

ALABAMA - AUBURN UNIVERSITY, 912

Genetics, breeding, and evaluation of certain forest trees in Alabama.

J. F. GOGGANS

UNIVERSITY OF ARIZONA, 2016-4168-025

Tree species for Christmas trees in the Southwest.

R. F. WAGLE

COLORADO STATE UNIVERSITY, 337

Morphological aspects of fruit development in spruce.

G. H. FECHNER

UNIVERSITY OF FLORIDA, 1293

Stock-scion relationships of southern pine.

W. H. SMITH

UNIVERSITY OF FLORIDA, 1344

Improvement of sand pine for reforestation of the Florida sandhills.

R. K. STRICKLAND and R. E. GODDARD

UNIVERSITY OF GEORGIA, 27

Improvement of forest tree species through genetics and breeding.

J. T. GREENE, M. REINES, and
K. STEINBECK

UNIVERSITY OF IDAHO, 3

Heritability and population structure of ponderosa pine.

C. W. WANG

SOUTHERN ILLINOIS UNIVERSITY, 69-B-1

Structural studies of early and delayed graft incompatibility in Juglans.

M. KAEISER

SOUTHERN ILLINOIS UNIVERSITY, 70-R-25

Genetic variability of apical dominance in black walnut (Juglans nigra L.).

P. L. ROTH and C. F. BEY

SOUTHERN ILLINOIS UNIVERSITY, 70-R-26

Selection of black walnut (Juglans nigra L.) for late flushing, cold hardiness, and rapid growth.

P. L. ROTH and C. F. BEY

SOUTHERN ILLINOIS UNIVERSITY, 71-R-10

Juvenile-mature correlations in black walnut.

F. H. KUNG

SOUTHERN ILLINOIS UNIVERSITY, 71-R-22

Genetic gain in black walnut using selection indices, variable selection methods and intensities.

F. H. KUNG and C. F. BEY

SOUTHERN ILLINOIS UNIVERSITY, 72-R-16

Use of twin study in estimating variance components in black walnut trees.

F. H. KUNG and C. F. BEY

KANSAS STATE UNIVERSITY, 771

Forest tree improvement for Kansas through selection and breeding.

R. W. FUNSCH

LOUISIANA STATE UNIVERSITY, 1591

Genetic improvement of southern hardwoods.

B. A. THIELGES

UNIVERSITY OF MAINE, 5011

Soil-tree relationships and their effect on tree growth in Maine.

R. A. STRUCHTEMEYER

UNIVERSITY OF MARYLAND, L-100

Vegetative propagation of pines by needle fascicles.

J. B. SHANKS

MICHIGAN STATE UNIVERSITY, 936

Genetic variation in physiological responses of trees to environment.

J. W. HANOVER

MICHIGAN STATE UNIVERSITY, 1061

Forest tree improvement through selection and breeding.

J. S. WRIGHT

MISSISSIPPI STATE UNIVERSITY, 601

Sycamore tree improvement for Mississippi.

S. B. LAND

UNIVERSITY OF MISSOURI, 164

Genetic investigations in forestation.

R. B. POLK

NORTH CAROLINA STATE UNIVERSITY, 4010

Physiological bases of genetic superiority.

T. O. PERRY

NORTH CAROLINA STATE UNIVERSITY, 4023

Variation of white oak in the southern Appalachians.

J. W. HARDIN and M. J. BARANSKI

NORTH CAROLINA STATE UNIVERSITY, 4039

Genetic evaluation of selected hardwoods of the southern United States.

R. C. KELLISON

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 2

White pine seed development in relation to sterility barriers, inbreeding depression and hybrid vigor.

H. B. KRIEBEL

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 7

Physiological genetics of forest trees.

D. B. HOUSTON

OKLAHOMA STATE UNIVERSITY, 1241

Clinal variation in shortleaf pine.

C. W. LANTZ

OKLAHOMA STATE UNIVERSITY, 1304

Improved loblolly and shortleaf pine.

C. W. LANTZ

OKLAHOMA STATE UNIVERSITY, 1348

Evaluation of shortleaf x slash pine hybrids.

C. W. LANTZ

OKLAHOMA STATE UNIVERSITY, 1349

Cottonwood improvement.

C. W. LANTZ

OREGON STATE UNIVERSITY, F-759

Genetic variation of Douglas-fir ecotypes in photo-response.

H. IRGENS-MOLLER

SOUTH CAROLINA - CLEMSON UNIVERSITY, 11-FR

An evaluation of growth impact loss caused by Cinaran aphid attack on selected southern pines.

R. C. FOX and K. H. GRIFFITH

SOUTH CAROLINA - CLEMSON UNIVERSITY, 704-FR

Genetics of forest trees.

R. E. SCHOENIKE

SOUTH CAROLINA - CLEMSON UNIVERSITY, 705-FR

Inbreeding Virginia pine.

R. E. SCHOENIKE

SOUTH CAROLINA - CLEMSON UNIVERSITY, 881-FR

Variation and inheritance of longleaf pine.

R. E. SCHOENIKE

UNIVERSITY OF TENNESSEE, 8

Christmas tree breeding.

E. THOR

TEXAS A&M UNIVERSITY, 1826

In vitro cultivation of wood plant cells.

D. F. DURSO

TEXAS - STEPHEN F. AUSTIN STATE UNIVERSITY, 2

Initial root growth and development in loblolly pines from "Lost Pines" and east Texas areas.

M. V. BILAN

TEXAS -STEPHEN F. AUSTIN STATE UNIVERSITY, 9

Testing river birch for silage cellulose production.

R. R. HICKS, JR.

VIRGINIA POLYTECHNIC INSTITUTE, 636159

Genetic evaluation of Ailanthus altissima (Mill.) swingle.

P. P. FERET

WASHINGTON STATE UNIVERSITY, 41

Development of superior seeds for plantation Christmas trees.

R. W. DINGLE and P. C. CRANDALL

WASHINGTON STATE UNIVERSITY, 1771

Genetics of multinodalness in lodgepole pine (Pinus contorta Dougl.).

R. W. DINGLE

WEST VIRGINIA UNIVERSITY, 1

Selection of valuable hardwoods.

F. C. CECI

PUBLICATIONS

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FOREST PROTECTION

Significant damage to forest resources is caused by wild fires. Even more important in recent years, diseases and insects have caused annual losses of billions of dollars to the national economy. Timber may be destroyed outright, or it may be gradually lost; many insects and diseases do not kill trees in a single year but reduce the growth or the usable wood over a longer period. A voracious insect now chewing its way through most of our Eastern forests, cities, and recreation areas is the gypsy moth. Once considered a minor forest pest, the gypsy moth has reached disastrous proportions. If uncontrolled, one insect larva can eat 1 square foot of tree leaves per day. An epidemic population of millions can rapidly defoliate and eventually kill the trees in forested suburban residential areas and parks. Insecticides may still be required for initial population reduction but newly isolated sex attractants confuse mating patterns and bring the moth under control. Increased emphasis is now being placed on the biological control of bark beetles, defoliators of forest trees, stem-canker rusts and other maladies now reducing forest productivity. Because the recognition of the values of city trees is growing, new programs are being developed to solve pest problems of shade trees in urban areas.

CONTROL OF INSECTS AFFECTING FORESTS

Research Problem Area 201

Insects exact a heavy toll of young trees each year, killing many and damaging and reducing the growth of surviving trees. Wildlife habitat is changed, and

fire danger is increased. Forest insect research can provide the information needed to reduce the continuing losses to forests and forest products, including Christmas trees. A sustained flow of new information provides the basis for safe, effective methods of control.

UNIVERSITY OF MICHIGAN, 14

Population regulation, beetles in aspen.

F. B. KNIGHT

This study of two Cerambycid beetles, Saperda inornata and Oberea schaumii has covered a period of approximately 8 years. During that time, the nomenclatural status of Saperda inornata was settled, the life history patterns of both beetles were determined, and their population regulation was investigated. The study has provided information on these two twig-infesting beetles that is of real value not only for knowledge of the species studied but also for an understanding of the behavior and regulation of other species of insects.

Life table analyses revealed that these insects have two major critical periods in their life cycles. The adult stage is extremely sensitive to environmental pressures and the early larval period is also critical. Once larvae became well established, the amount of mortality was found fairly constant, despite the effects of several predators and variable environmental conditions. Adults were long-lived when protected in cages but field tests revealed that they were rather poor in flight and sensitive to weather extremes. Most failed to produce their full complement of eggs.

The beetles infested small stems of aspen suckers and the limbs of larger trees. They were attracted to sunny locations and were most common in rather sparse stands of aspen. Oberea schaumii dispersed much more widely than Saperda inornata and penetrated into more shaded locations.

TEXAS-STEPHEN F. AUSTIN STATE UNIVERSITY, 11

Flight and attack behavior of IPS bark beetles.

J. E. COSTER

First-year studies have centered on determining daily and seasonal emergence patterns of the Ips avulsus, Ips grandicollis, and Ips calligraphus in eastern Texas. Studies also were initiated to determine flying-height patterns of the three Ips in relation to stand density, stand height, and understory density.

Five species of nematodes have been found to commonly infest Ips in eastern Texas. The degree of infestation by the nematodes for each bark beetle species during 1972 was at a low of 20-30 percent during January and February and reached a high of 50-60 percent in July and August. Continuing studies are investigating the influences of nematode infestation on bark beetle fecundity, brood development periods, and anatomical variations in the bark beetles.

WASHINGTON STATE UNIVERSITY, 0102

Computer simulation of the population dynamics of Scolytus ventralis infesting Abies Grandis.

A. A. BERRYMAN and L. V. PIENAAR

Population data collected over the past 8 years have been partially analyzed. Major conclusions were:

1. Fir engraver populations seem to be food limited and outbreaks appear to be correlated with epidemics of a defoliator, the Douglas-fir tussock moth.
2. Intraspecific competition is a significant population regulator, and survival from competition is directly related to food quantity.
3. Nematode parasitism and interspecific competition may be influential in the suppression of outbreaks.

The conceptual framework for a population model was developed, and a preliminary computer model constructed for the within-tree survival component. Work is proceeding on models to describe stand growth, insect dispersal, and insect attack, and some preliminary simulations have been run. Work is continuing on the mechanism of host resistance to insect attack. Monoterpenes have been identified in resistant reaction of grand fir which are not present in the normal host resin system. Work is also progressing on the identification of polyphenolics associated with these wound reactions.

ADDITIONAL PROJECTS

UNIVERSITY OF ARKANSAS, 611

The control of pine sawflies in Arkansas with special reference to the use of biological control.

L. O. WARREN and J. P. FULTON

UNIVERSITY OF ARKANSAS, 656

Significance of Ips bark beetles and associated fungi causing death of pine in Arkansas.

W. C. YEARIAN

UNIVERSITY OF ARKANSAS, 662

Control of insects affecting seed production of loblolly and shortleaf pines in Arkansas.

W. C. YEARIAN

COLORADO STATE UNIVERSITY, 329

Chemical control of bark beetles: effects of cacodylic acid on tree phloem constituents.

C. P. P. REID

CONNECTICUT AGRICULTURAL EXPERIMENT STATION - NEW HAVEN, 331

Utilization of pathogens for the control of forest defoliating insects.

H. K. KAYA

CONNECTICUT AGRICULTURAL EXPERIMENT STATION - NEW HAVEN, 332

Relationship of insect numbers to defoliation and mortality of forest trees.

D. M. DUNBAR and G. R. STEPHENS

CONNECTICUT AGRICULTURAL EXPERIMENT STATION - NEW HAVEN, 333

Pheromone and hormone use to control gypsy moth and elm spanworm populations.

J. GRANETT

UNIVERSITY OF GEORGIA, 26

The biology and control of insects affecting forest management in Georgia.

R. T. FRANKLIN

UNIVERSITY OF HAWAII, 928

Bio-ecology of the Koa Psyllid, Psylla uncatoides (Ferris and Klyver), on native Acacia spp. trees.

J. W. BEARDSLEY

UNIVERSITY OF IDAHO, 13

Bionomics and control of cone and seed insects.

J. A. SCHENK

UNIVERSITY OF IDAHO, 17

Influence of natural and manipulated stand characters on S. ventralis population and damage level.

J. A. SCHENK

KANSAS STATE UNIVERSITY, 671

Biology and control of insects and related arthropods attacking forest and windbreak tree species.

H. E. THOMPSON

UNIVERSITY OF KENTUCKY, 484

Microbial control of important lepidopterous and hymenopterous defoliators of Kentucky forests.

G. L. NORDIN

UNIVERSITY OF MAINE, 5007

Biology and control of the balsam gall midge.

E. A. OSGOOD

UNIVERSITY OF MAINE, 5012

Factors affecting the regulation of spruce budworm populations.

D. E. LEONARD

UNIVERSITY OF MAINE, 5013

Biology and ecology of hardwood defoliators.

D. E. LEONARD and P. W. SCHAEFER

UNIVERSITY OF MARYLAND, H-101

Survey and evaluation of Maryland forest insects.

A. L. STEINHAUER, F. E. WOOD,
and J. A. DAVIDSON

UNIVERSITY OF MICHIGAN, 22

Insects affecting sugar maple in northern Michigan.

J. A. WITTER

MICHIGAN STATE UNIVERSITY, 942

Investigations on auto-stability of the arthropod component in single species conifer.

W. E. WALLNER

MICHIGAN TECHNOLOGICAL UNIVERSITY; 2-3119

Biological control of pine bark aphid in forest nurseries.

N. F. SLOAN

MISSISSIPPI STATE UNIVERSITY, 623

Bionomics and control of insects affecting seed production in pine seed orchards with emphasis on coneworms, *Dioryctria* spp.

W. W. NEEL and P. P. SIKOROWSKI

UNIVERSITY OF MISSOURI, 149

Insects associated with forest and plantation communities.

W. H. KEARBY

UNIVERSITY OF NEW HAMPSHIRE, 4

Oribatei and collembola in soils of white pine cover type.

R. M. REEVES

UNIVERSITY OF NEW HAMPSHIRE, 9

Predator dispersion and tree growth loss during saddled prominent defoliation.

R. M. REEVES and J. P. BARRETT

NEW JERSEY - RUTGERS UNIVERSITY, 436

Metabolism of insecticides by the gypsy moth (*Porthetria dispar*).

A. J. FORGASH and S. AHMAD

NEW JERSEY - RUTGERS UNIVERSITY, 518

Activation of a latent nuclear polyhedrosis virus infection of the gypsy moth, *Porthetria dispar*.

D. PRAMER

NEW MEXICO STATE UNIVERSITY, 7

Biology and host-finding mechanisms of the ponderosa pine cone beetle in New Mexico.

H. G. KINZER

STATE UNIVERSITY OF NEW YORK, 201-5-6

Enzymology of insecticides biodegradation.

T. NAKATSUGAWA

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 3

Integrated control of the insect and mite pests of pine trees.

D. G. NIELSEN

OREGON STATE UNIVERSITY, 868

Seed and cone insect pests of Douglas-fir.

W. P. NAGEL

PENNSYLVANIA STATE UNIVERSITY, 1750

Development of the eastern spruce gall aphid and its control.

E. A. CAMERON

SOUTH CAROLINA - CLEMSON UNIVERSITY, 905

The biology of pine reproduction weevils in coastal South Carolina.

R. C. FOX

TEXAS A&M UNIVERSITY, 1525

Electrophysiology of pheromone reception in the southern pine beetle and related bark beetles.

T. L. PAYNE

UNIVERSITY OF WASHINGTON, 22

A study on the orientation of bark beetles (coleoptera: Scolytidae).

R. I. GARA

UNIVERSITY OF WISCONSIN, 1784

Influence of host-origin anti-feedants on sawfly behavior.

D. M. BENJAMIN

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Incidence of occurrence of *Beauveria bassiana* (Bals.) Vuill in forest collections of *Hylobius pales* and *Pachylobius picivorus* weevils (Coleoptera: Curculionidae). *Canadian Entomologist*. 104. 1972.

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WINGFIELD, MELVIN, and L. O. WARREN

The effect of photoperiod on the development of the sawfly *Neodiprion taedae linearis*. *Journal of Kansas Entomological Society*. Vol. 45. pp. 1-6. 1972.

YEARIAN, W. C., and S. Y. YOUNG

Evaluation of new insecticides for control of the loblolly pine sawfly. *Arkansas Farm Research*. Vol. 21. p. 3. 1972.

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Effect of the blue stain fungus, *Ceratocystis ips*, on development of *Ips* bark beetles in pine bolts. *Annals Entomological Society of America*. Vol. 65. pp. 481-487. 1972.

YOUNG, S. Y., J. M. LIVINGSTON, J. A. McMASTERS, and W. C. YEARIAN

A nuclear polyhedrosis virus of the loblolly pine sawfly, *Neodiprion taedae linearis* Ross. *Journal of Invertebrate Pathology*. Vol. 20. pp. 220-221. 1972.

CONTROL OF DISEASES, PARASITES, AND NEMATODES AFFECTING FORESTS

Research Problem Area 202

Forest disease research is essential to protect and enhance the social and economic value of trees in forests and farm woodlots. Diseases reduce the utility of trees for wildlife habitat and timber production. They kill trees, discolor foliage, retard growth, and cause decay leading to breakage and windfall. Prolonged droughts, wet periods, and changing climatic conditions accentuate tree disease problems.

UNIVERSITY OF CONNECTICUT, 418

Etiology and epidemiology of a diffuse canker on eastern hemlock.

D. B. SCHROEDER

In 1970 numerous eastern hemlock were reported dying in a nursery located in northwestern Connecticut. Preliminary investigations revealed a basal stem canker on the majority of dead and dying trees. Approximately 88 percent of the trees eventually died and 80 percent of the remaining trees, including those planted as replacements for dead trees, were cankered. Isolations from cankered trees in the planting yielded numerous species of fungi and bacteria including two fungi, Phomopsis sp. and Cytospora sp., reported to be pathogenic on hemlock. Hemlock seedlings growing in the greenhouse were inoculated with isolates of both fungi. Ninety percent of the trees inoculated with Phomopsis sp. and 30 percent of the trees inoculated with Cytospora sp. developed cankers. Investigations are being made in an attempt to explain the extremely high incidence of disease in the nursery planting. There was no correlation between wounding and exposure and incidence of disease. Soil moisture studies indicate that the soil in the nursery is poorly drained. Tests are being made to determine if hemlock trees growing on a poorly drained site are predisposed to infection by one or both of the above pathogens.

In an initial survey of ornamental plantings in Connecticut, Phomopsis sp. and Cytospora sp. were found to be consistently associated with cankered hemlocks.

UNIVERSITY OF IDAHO, 11

Decays of inland-northern timber trees.

A. D. PARTRIDGE

In grand fir, decay in increment borings and the percentage of trees with conks provide reliable means for estimating volume loss in stands. We calculated regression equations for this prediction.



Figure 16. Blasting breaks rotted roots; the sound ones remain intact. University of Idaho, 11.

Strong relationships exist between root rots and beetle attacks. Therefore, we modified our procedures during the summer by using dynamite to expose the roots of all cut trees, and we employed a crew of both pathologists and entomologists. In 97 percent of the cases where root rot occurred, bark beetle attacks were present. Complexes of organisms rather than a single insect or fungus were associated with mortality. The most common complex consisted of Poria weirii and Fomes nigrolimitatus as decayors and Pseudohylesinus granulatus and Scolytos ventralis as bark beetles.

It was possible to predict the complexes using specific plant indicators. For example, if Coptis sp. was present, P. weirii and F. nigrolimitatus usually were causal; and if Valeriana sp. was present, Armillaria mellea was causal. The hue of crown discoloration is not a reliable indicator of causes of mortality. Neither specific fungus or insect nor a differentiation between fungus or insect-caused mortality could be discerned by crown hue.

Blasting was a very effective means of surveying both for root disease and root-inhabiting insects, provided the blasts are low-powered and controlled (fig. 16). The process can be taught to technicians. Estimates of root rot using axe cuts on the stump and exposed roots included only 59 percent of the root rot instances exposed by blasting. Increment boring also was ineffective in locating root rots: only 9 percent of instances were so detected.

UNIVERSITY OF TENNESSEE, 7

Blight resistance in American chestnut.

E. THOR

Three different approaches are used in the breeding effort to develop American chestnut trees with resistance to the blight (Endothia parasitica). First, several thousand nuts have been irradiated (3,000 r) and the seedlings outplanted in a testing orchard. Some of these trees are now more than 10 years old, but

so far none have shown a high degree of resistance. Second, over thirty large living American chestnut trees have been located in the Southern Appalachians; most of them have been grafted into a breeding orchard. Many of the grafted trees are now flowering, enabling successful crosses to be carried out. Test plantations of control- and open-pollinated progenies will be started in the spring. Third, investigations of the relationships of tree chemistry with resistance have been carried out for several years. If chemicals determining degree of resistance can be identified, reliable early selection criteria may be developed. To date, 225 phenolic components from inner bark extracts have been separated. Differences in chromatographic pattern were noted between American chestnut sound bark extracts and infected inner bark extracts from the same trees. When bioassayed, extracts from infected bark were most inhibitory.

ADDITIONAL PROJECTS

ALABAMA - AUBURN UNIVERSITY, 907

Biology of fungal pathogens associated with seedling diseases, forest nurseries and plantations.

W. D. KELLEY

UNIVERSITY OF ARIZONA, 2016-4166-23

Diseases and decay of woody plants on Arizona watersheds and recreational areas.

R. L. GILBERTSON

UNIVERSITY OF ARKANSAS, 663

Organelles of fungi causing forest-tree diseases.

F. H. TAINTER

UNIVERSITY OF ARKANSAS, 741

Plant viruses in forested areas.

J. P. FULTON, J. M. McGUIRE
and H. A. SCOTT

UNIVERSITY OF ARKANSAS, 751

Tree stem blister rusts in Arkansas with emphasis on development of genetic resistance.

F. H. TAINTER

UNIVERSITY OF CALIFORNIA, 2800

Ecology, impact, and control of root pathogenic fungi of forest trees.

F. W. COBB, J. R. PARMETER,
and R. D. RAABE

UNIVERSITY OF CALIFORNIA, 2348

Microbiology and pathology of wetwood in California firs.

W. W. WILCOX

UNIVERSITY OF FLORIDA, 1446

Epidemiology of fusiform rust.

R. A. SCHMIDT

UNIVERSITY OF HAWAII, 721-F

Natural microbial antagonism in forest soil of Hawaii.

W. KO

LOUISIANA TECH UNIVERSITY, 22

Effects of controlled burning on soil microorganism populations in Robert's plots, Urania, Louisiana.

E. R. ANDRULOT, J. MURAD,
and S. BAMFORTH

LOUISIANA TECH UNIVERSITY, 52

Morphology and cytology of fusiform and gall rust in five pines inoculated with isolates of each species.

F. F. JEWELL

UNIVERSITY OF MARYLAND, J-101

Forest tree seedlings and soil fungi relationships.

W. L. KLARMAN

UNIVERSITY OF MICHIGAN, 19

The influence of air pollutants on the host-parasite interaction.

H. L. MORTON

UNIVERSITY OF MINNESOTA, 22-18

Dwarf mistletoe.

D. W. FRENCH, M. P. MEYER,
and F. D. IRVING

UNIVERSITY OF MISSOURI, 294

Ultrastructure of mycorrhizal associations and pathogenic fungi.

M. F. BROWN

NORTH CAROLINA STATE UNIVERSITY, 4012

Ecology of forest tree diseases and wood deterioration.

L. F. GRAND and E. B. COWLING

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 8

Disease problems in plantation trees of Ohio.

C. LEBEN, H. R. KRIEBEL,
and B. THIELGES

OREGON STATE UNIVERSITY, F-819

Phytophthora root rot of Port-Orford-cedar.

L. F. ROTH and L. ENGLANDER

PENNSYLVANIA STATE UNIVERSITY, 1702

Epidemiology of forest tree diseases.

F. A. WOOD

PENNSYLVANIA STATE UNIVERSITY, 1825

An annual canker of maple.

W. W. VARD, F. A. WOOD,
and T. W. BOWERSOX

SOUTH DAKOTA STATE UNIVERSITY, 592

The identity, extent, and control of forest, shade and shelterbelt tree diseases in South Dakota.

J. D. OTTA

UNIVERSITY OF TENNESSEE, 15

Mycorrhizae for biological control of soil-borne fungi.

F. W. WOODS

TEXAS A&M UNIVERSITY, 1526

Etiology and control of live oak decline.

E. P. VAN ARSDEL

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J. E. KUNTZ

UNIVERSITY OF WISCONSIN, 1434

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R. F. PATTON

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PREVENTION AND CONTROL OF FOREST AND RANGE FIRES

Research Problem Area 203

Fire research develops the knowledge for safeguarding more than 1 billion acres of public and private forest and range lands. Fires create air and water pollution, damage outdoor recreation, destroy natural beauty, injure natural resource-based industries, sweep rural communities and even cities, and take human lives. More than 150,000 forest fires occur annually. Development of new fire prevention methods to reduce the number of fires, new technology for fuel hazard reduction, and improved systems for fire detection and effective attack on threatening fires is needed.

ADDITIONAL PROJECT

UNIVERSITY OF MONTANA, 3005

Fire in natural stands--influences and smoke dispersal.

R. STEELE and R. NORUM

HARVESTING, PROCESSING, AND MARKETING OF FOREST PRODUCTS

Efficient utilization of the trees cut in our Nation's forests can increase present yields 20 to 30 percent. Greater efficiency will not come easily, however, because it must overcome traditional apathy, inefficient management, antiquated harvesting techniques and market instability. Getting forest products from the woods to the ultimate consumer is a continual challenge since costs must be minimized and production maximized. Good utilization not only involves more careful logging methods and optimal use of tree tops and large branches but also the recycling of used forest products. Techniques are being developed to recondition second-hand lumber and to recover wood scraps from construction, demolition, and dunnage wastes to make paper and other products. Increasing amounts of waste paper are being recycled to produce more paper.

Improvement of harvesting and transportation systems is needed to bring new sources of inaccessible timber to market, harvest small-sized trees and sort municipal forest wastes in cities. Large acreages of commercial timber in the eastern United States now held by absentee owners needs to be harvested through cooperative endeavors of landowners. Our present estimates of future forest products requirements are not accurate enough for industrial development; better estimates of long-range wood demands are needed to point the directions for planning.

RESEARCH ON MANAGEMENT RESEARCH

Research Problem Area 114

The resources which would be required to effectively conduct the research on all the researchable problems confronting us greatly exceed those available. Thus, it is necessary to decide which research to support and at what level of funding. To date there is a paucity of information available to make such decisions. Consequently, it is essential to conduct research which will lead to more reliable estimates of the benefits and costs of specific research proposals so that the objectivity of the decisionmaking process can be improved. Research on research management also involves studies on maximizing employee and research facility productivity, and coordinating research effort among scientists throughout the Nation.

ADDITIONAL PROJECT

WASHINGTON STATE UNIVERSITY 136

Implementing research results for producers and consumers of forest products.

R. J. HOYLE, JR.

NEW AND IMPROVED FOREST ENGINEERING SYSTEMS

Research Problem Area 302

Improved forest engineering systems can reduce timber harvesting costs, increase and stabilize rural payrolls, reduce accidents, and provide higher returns to industry. Over 100 billion board feet of timber in Alaska and the western States are inaccessible because of the high cost of road construction, steep terrain, soil conditions, and lack of equipment suitable for timber harvesting. In other States, because of the high proportion of small-sized timber and the high percentage of defective timber, the economic feasibility of harvesting is limited.



Figure 17. Hardwood logging residue of various shapes and sizes is easily reduced to chips by the chip harvester. Chips can be blown directly into vans (at left in photograph), or they can be screened on the site with a portable screen. Michigan Technological University, 2-3310.

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3310

Pulpwood skidding time analysis in the Keweenaw Peninsula, Michigan.

H. M. STEINHILB

Improving the utilization of wood fiber produced by America's forests is a vitally important responsibility of forest scientists. Logging residue -- tops of trees, large branches and cull logs -- heretofore has been uneconomical to harvest. These materials which are the residue of every logging operation provide an untapped source of wood fiber, and this research highlights both the methods and economics of using this "new" source of wood fiber.

The chip harvester, (fig. 17) a new machine capable of chipping logging residue from selectively cut northern hardwood forests, was used to provide essential time and cost facts. Logging residue from sugar maple and birch trees as large as 2 feet in diameter was processed during conduct of the research. In this work 182.6 tons of chips were produced during 171 man hours and 62.5 machine

hours spent on the project. Profits were estimated at \$1.20 per ton, green weight, delivered to the paper mill. Avoidable delays, damage to the residual stand, and other unfavorable factors were all evaluated in this pioneer research. A total of 31.9 acres of logging residue was skidded to central yarding areas in the forest and processed into chips on the site. The average was 12 treetops or cull trees per acre and these produced an average of 8.5 tons of chips for each acre of selectively logged forest. It is forecast that increasing attention to this source of wood fiber will be made in the United States as demand for pulp and paper fiber increases. Therefore, as a relevant estimate derived from facts obtained during this study, about 5,500 to 6,000 acres of logging residue from selectively cut hardwood forests would be required to produce 50,000 tons of chips per year.

OREGON STATE UNIVERSITY, 870

Relationship of timber harvesting systems to logging residue.

H. A. FROEHLICH

Loggers and foresters are increasingly concerned with the effect of tree tops, broken chunks, and cull logs that fall into or near streams during logging, especially on steep slopes. This material may aggravate downstream flood damage to roads and other improvements, trigger stream channel scouring, physically interfere with fish movements, and damage fish habitat. Sometimes costly debris removal is required, with uncertain results. Measures to prevent debris from getting into the stream-side area may be the best solution to the problem.

This study is comparing three variations of highlead logging to determine their impacts on streams: (1) conventional highlead cable yarding, (2) cable-assisted felling with cable yarding (fig. 18), and (3) conventional highlead yarding using a stream-side buffer strip of uncut trees. In uncut, old-growth Douglas-fir forests of the Western Cascades, an average of 738 cubic feet of fallen timber is found per 100 feet of stream channel in a 30-foot wide strip. After timber felling and before yarding, the increases in material reaching the channel were 8.1, 1.9, and 1.1 times the original quantities for the three logging systems, respectively. In the settings so far measured after yarding, only about 30 percent of the pre-logged material remains in the channel areas because down, sound material is removed and is replaced by a lesser volume of fine debris. Preliminary results suggest that cable-assisted directional felling greatly reduces breakage and lessens residue. Wind-throw and post-logging mortality in buffer strips has not yet been evaluated.

ADDITIONAL PROJECTS

LOUISIANA STATE UNIVERSITY, 1444

The development of timber harvesting systems for the southeastern United States.

R. W. McDERMID



Figure 18. Cable-assisted felling keeps trees out of stream channels and it also reduces breakage of the trees since they are felled uphill. Less residue results and damage to streams is reduced. Oregon State University, 870

NORTH CAROLINA STATE UNIVERSITY, 4036

Time-lapse photography for analysis of logging systems.

A. G. MULLIN and E. L. DEAL

OREGON STATE UNIVERSITY, F-911

Skyline logging systems for managing young forest stands.

D. E. AULERICH and H. A. FROEHLICH

UNIVERSITY OF VERMONT, 16

Effect of high-vacuum pumping systems on the sugar maple tree and its sap.

F. M. LAING

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ECONOMICS OF TIMBER PRODUCTION

Research Problem Area 303

Timber production efficiency research investigates how income can be increased through effective use of labor and capital. Such information is generally lacking for the wide variety of forestry investments possible in different areas. Returns of expenditures for planting, stand improvement, and other timber growing activities vary widely throughout the Nation and depend on many cost factors, including the quantity and quality of timber yields and local market conditions. Identifying the most profitable opportunities for management of public forestry programs and for private investments on forest lands is basic to efficient allocation of the funds available for timber growing.

UNIVERSITY OF CALIFORNIA, 2349

Determination of optimum production schedules by mathematical programming.

D. E. TEEGUARDEN

To improve nursery management, a mathematical model for simulating the operation of forest tree nurseries in California was developed and tested. The model depicts the behavior of seed crops, seed collection, tree production, seedling demand, tree order allocation among different nurseries, and cost of system management -- all under stochastic conditions. A linear programming model is used to derive decision rules for allocating tree orders to minimize total costs of production and distribution. Different management policies were simulated with the following results.

The decision to shut down the Mt. Shasta Nursery (in 1968) apparently was an effective cost-saving action in that the total cost of meeting current tree demands is lower without the nursery than with it. Further, the remaining two-nursery system can handle up to a 50-percent increase in tree demands, though at increasing marginal cost. In general, nursery seed should be collected only during heavy crops. When seed is collected, the amounts should be sufficient to operate the nurseries for a minimum period of 8 years.

UNIVERSITY OF GEORGIA, 28

Economics of timber production and timber land management.

J. L. CLUTTER, J. C. FORTSON,
and L. A. HARGREAVES

This study seeks to determine the proper decisionmaking criterion for use when choosing among competing forestry investment opportunities. Formulations establishing a "best" criterion already exist but generally they require the assumption of perfect capital markets, a simplification that obviously fails to reflect the true situation. The study develops the concept of a globally optimum policy for determining the proper investment rule under different market conditions. A globally optimum policy is defined as the management strategy that maximizes liquidation value; that is, the market value of all owned assets of the enterprise, for each and every point in a finite planning period.

Models of a profit-oriented forestry enterprise practicing even-aged forest management were formulated for various capital market conditions: perfect capital market, no capital market, absolute debt limit, internal generation of funds, maximum debt-equity ratio, and different lending and borrowing rates. Dynamic programming was used to maximize the liquidation value of the firm for each year of a finite planning period. An investment rule was sought that led to adopting the globally optimal policy.

The effect of following a nonoptimal strategy was studied by comparing projected liquidation value with the maximum liquidation value attainable. Sensitivity of optimal liquidation value to changes in investment strategies and land prices was also investigated.

The perfect capital market case is the one market condition for which a globally optimal policy was found to exist. Maximizing net present value under conditions of a perfect capital market model leads to the adoption of a globally optimal policy. Hence, maximization of net present value is an optimal investment rule under a perfect capital market. Optimal strategies for the other models were found to vary with the portion of the planning period for which liquidation value was being maximized. No globally optimal policy, therefore, existed for them. Conditions necessary for existence of a globally optimal policy are demanding, and the use of that criterion for selecting the proper investment rule appears limited. The better understanding of the behavior of forestry investments under realistic market conditions will be of value to those concerned with forest finance.

LOUISIANA TECH UNIVERSITY, 61

Workmen's compensation and safety in timber harvesting and wood-using mills, Arkansas and Louisiana.

J. E. CAROTHERS

Although Louisiana has a law which requires motor vehicle liability insurance (MVLI), a preliminary investigation among 19 pulpwood dealers, who receive wood from 600 producers, reveals that 40 percent of producers' trucks in northern Louisiana are not insured. Dealers without MVLI prefer such coverage but, if one required it, producers might switch to other dealers or resign. High costs of premiums was given as another reason for no coverage.

A minimum policy (\$5/10/5M) set by the State cost \$290 per truck in 1971; a \$10/20/10M policy cost \$350. A dealer may purchase "extended coverage" for his protection.

One of four pulp-paper firms in the area required dealers to carry MVLI on all trucks which transport wood received by that mill. This policy appears to be expressed in contracts with dealers. Nine of the 19 dealers favor a no-fault insurance law; a Federal statute is preferred.

Tentative recommendations are: (1) The law should be enforced. A vehicle owner should exhibit a certificate of insurance when license plates are purchased. Minimum policy should be \$10/20/10M. (2) Companies should require dealers to abide by all State and Federal laws. In effect all trucks would be covered. (3) The Congress should pass a no-fault law or set minimum standards. (4) An analysis of accident records is needed by types and uses of vehicles. This might lead to MVLI rates based on particular data rather than on an average of all vehicles as is currently practiced.

The investigation was expanded in June 1972 to cover all of Louisiana and Arkansas and to add logging trucks.

NORTH CAROLINA STATE UNIVERSITY, 4033

Economic assessment of hardwood production.

D. L. HOLLEY

The major accomplishment of this project was the development of cubic foot yield tables for well-stocked, natural, even-aged stands of mixed hardwoods for a variety of site conditions in the South. The data base was 642 fifth-acre plots made available by the North Carolina State University Hardwood Research Cooperative. Yield tables were developed separately and in various combinations for muck swamps, peat swamps, black river bottoms, branch bottoms, wet flats, red river bottoms, piedmont bottomlands, coves and lower slopes, and upland slopes and ridges. Economic analysis of the data resulted in the following general conclusions. None of the site types examined are producing as much as a cord/acre/year in natural stands on pulpwood rotations. The average productivity of the data base is 0.75 cord/acre/year. Using \$3.50/cord



Figure 19. This bottomland hardwood site in the Natural Coastal Plain is typical of many areas in the Southeast. A major problem is that hardwoods are overstocked, which causes a high basal area and a low average diameter. North Carolina State University, 4033.

for stumpage, \$1/acre annual costs, and 6 percent interest, soil expectation values (before tax) scaled downward from \$13/acre for pulpwood rotations and averaged \$7/acre for all sites combined. For maximum value production in natural hardwoods, stands will have to be held long enough for sawtimber to develop. Using current sawtimber prices and a 40-year rotation, a soil expectation value of \$50/acre can be generated for black river bottoms, the most productive site type. The natural hardwood stands in the data base are overstocked (fig. 19) which results in high basal area and low average diameter. Management input to control species composition and distribute the basal area among fewer stems would apparently be economically feasible for sawtimber rotations.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2447

Financially optimum thinning regimes for mixed-conifer forests of California.

R. F. GRAH

MICHIGAN STATE UNIVERSITY, 978

Financial evaluation of forest management opportunities.

V. J. RUDOLPH

UNIVERSITY OF MISSOURI, 166

Wood industries management.

K. T. ADAIR

UNIVERSITY OF MISSOURI, 168

Allocations of inputs among timber production opportunities.

R. C. SMITH

NORTH CAROLINA STATE UNIVERSITY, 4021

A study of computer simulation and its potential benefit to forestry and the wood-using industries.

A. G. MULLIN

NORTH CAROLINA STATE UNIVERSITY, 4037

Economics of an integrated firm's alternatives in managing hardwood sites for fiber production.

D. L. HOLLEY

SOUTH CAROLINA - CLEMSON UNIVERSITY, 707

Logging costs.

W. A. SHAIN

UNIVERSITY OF TENNESSEE, 10

Economics of alternative timber-growth practices in Tennessee hardwood stands.

G. R. WELLS

VIRGINIA POLYTECHNIC INSTITUTE, 636183

Economic aspects of decisions involving intensive forest management in Virginia.

E. F. THOMPSON

UNIVERSITY OF WISCONSIN, 1571

Computer simulation of sampling designs and management practices in forestry.

L. G. ARVANITIS

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NEW AND IMPROVED FOREST PRODUCTS

Research Problem Area 401

The objectives of forest products research are to develop (1) lower cost products with greater desirability, serviceability, and performance, and (2) greater use of low-quality timber, little-used species, and materials now remaining as waste.

The quality of available timber continues to decline because of the lack of adequate replacements for larger and better quality trees. Demand for timber products is expected to go up 80 percent by the year 2000. Research is needed to develop ways to convert more low-grade material into useful products. Where such timber is abundant, it may be possible to establish new industries and enhance economic growth. Improved wood utilization also provides a profitable means for upgrading residual stands. Use of low-quality trees frees space for better growing stock.

ALABAMA-AUBURN UNIVERSITY, 910

Strength of plastic-overlaid pine plywood and particleboard.

E. J. BIBLIS

Southern yellow pine plywood can be successfully used as a core for structural sandwich panels with fiberglass reinforced plastic faces. Such panels can be used in fabrication of marine shipping containers for side and end walls and roofs.

Structural properties of plain southern yellow pine plywood in dry condition fastened to the containers frame would satisfy structural requirements for the walls. Reinforcement of faces with resin-impregnated fiberglass would satisfy other important requirements such as wetting proof, resistance to weathering and increased durability, improved appearance, and easier maintenance.

For determination of certain properties of reinforced pine plywood panels, composite panels were constructed with 5/8" select pine plywood for cores. Two types of fiberglass and resins were used: (a) fine glass cloth impregnated with a modified polyester resin, and (b) woven-roving glass with polyester resin. Experimental results reveal the following. First, under specific and controlled laminating conditions, an excellent bond (90 percent wood or fiberglass failure) can be obtained between the reinforced glass and pine plywood, even on latewood zones. Second, certain composite panels tested in flexure with the face grain of plywood parallel to span were 30-percent stiffer and 61-percent stronger than plain plywood. Third, composite panels tested with the face grain of plywood perpendicular to span were 113-percent stiffer and 150-percent stronger than plain plywood tested similarly. Fourth, edgewise shear strength and edgewise shear modulus of composite panels are approximately 100-percent higher than corresponding properties of pine plywood of equal thickness.

NORTHERN ARIZONA UNIVERSITY, 2.

Wood quality of southwestern ponderosa pine in relation to growth characteristics.

G. VOORHIES

Fifty-eight young-growth ponderosa pine trees growing in northern Arizona and northern New Mexico have been destructively sampled to yield cross-sectional disks at 5-foot intervals along the bole to a 4-inch top. Increment cores were taken at dbh. Specific gravity was calculated for all disks and cores. Wood volume, bark volume, and weighted specific gravity were computed for each 5-foot bolt section. Average whole tree specific gravity for the entire sample was 0.3745. Prediction equations were of the form $\hat{Y} = a + bx$, where \hat{Y} = whole tree specific gravity, and x = increment core specific gravity. These resulted in correlation coefficients from 0.634 to 0.82, depending on the size of the increment core and the number of cores extracted. Regression analysis of wood cubic foot volume on the combined variable (d.b.h.i.b.² x height) resulted in an r value of 0.995, indicating reliable data suited to a volume table. Regression analysis of cubic foot bark volume on (d.b.h.o.b.² x height) resulted in an r value of 0.84, which may be used as the basis of a bark volume table. Other analyses are in progress.

INDIANA-PURDUE UNIVERSITY, 1355

Mechanical behavior of wood-base composite media.

M. C. HUNT

The bulletin "The Durability of Plywood Structures" is a unique compilation of the history and performance of exterior plywood and composite plywood structural panels in farm structures fabricated at Purdue during the 1940's. The report couples the limited background information on the original 1940 research project with subsequent first-hand field observations of portable plywood hog houses. These structures showed an amazing ability to function in a highly effective way for periods continuing beyond 25 years in an extreme-use

environment that requires durability and resistance to dynamic stresses. The exemplary performance of these houses suggests that similar construction in conditions of drastically reduced exposure hazards -- for example, residential buildings -- could be expected to last almost indefinitely.

The paper "Finite-Element Analysis of Flakeboard" develops a model for predicting the modulus of elasticity in tension of a homogeneous flakeboard as a function of its ingredients. The basic concept emphasized is that of the idealization of the composite as a structural system consisting of elements which are arranged and joined together in a prescribed manner. The mechanical properties of these elements are assigned certain values determined by the actual material they replace. From the force-deformation relation of the structural analog, the tensile modulus of the flakeboard is predicted.

MICHIGAN STATE UNIVERSITY, 1049

Decay and termite resistance of Michigan woods and derived products.

E. A. BEHR

In Michigan, an extensive growing reserve of northern white cedar with little cutting indicates that more information about its properties is needed. The heartwood was found to be far more resistant to subterranean termites than the sapwood or the sapwood of southern pine. Heartwood from bog-grown and upland-grown trees was equally resistant. There was slightly more attack on inner than outer heartwood. Tree diameter, growth rate or height did not significantly influence termite resistance.

Using *Lenzites trabea* and *Poria monticola* as decay fungi in the soil-block test, resistance to decay in heartwood from 30 bog-grown cedar trees decreased from butt to top. Inner heartwood was less decay-resistant than outer heartwood, especially in butt logs. Resistance varied greatly from tree to tree. By the ASTM rating scale 93 percent of the trees had heartwood highly resistant to *L. trabea* and 77 percent had heartwood highly resistant to *P. monticola*. Age of tree, diameter, and growth rate had no important influence on decay resistance. The trees varied in diameter of the butt log from 16.2 to 30.5 cm, in age from 46 to 132 years, and in growth rate from 4.4 to 9.5 rings per cm.

UNIVERSITY OF MINNESOTA, 19-62

Methods of improving and predicting the long-term behavior of particleboard.

J. G. HAYGREEN and R. O. GERTJEJANSEN

The performance of phenolic bonded wafer-type particleboard produced with additional impregnating resins was evaluated. Wafer-type particleboard will likely find considerable use as an alternative to plywood, when three plants, now under construction in North America, are completed. If the board is used under severe moisture conditions, dimensional change, surface deterioration and deleterious effects upon strength will need to be minimized. One possible method is adding phenolic impregnating resins to the furnish prior to the

normal blending phase of manufacture. Seven percent impregnating resin was applied to both green and dried wafers and properties were compared with conventional wafer-type particleboards containing only bonding resin. Linear swell was not improved by the additional resin but all other properties were drastically improved. The resin impregnation method of improving board properties was compared with post-steaming and post-heating, procedures developed by other researchers. Post-steaming boards for 10 minutes in 360° saturated steam or the addition of 12 percent impregnating resin are about equally effective in increasing dimensional stability. However, because of other deleterious effects of post-steaming and the high cost of impregnating resins, the post-heating treatment apparently has the best chance of industrial application. Where surface properties are of concern, such as in siding, the resin treatment would provide the most serviceable product.

MISSISSIPPI STATE UNIVERSITY, 3626

Laminated hardwood lumber for furniture manufacture.

JOE YAO

The objective of the study was to develop techniques for producing laminated hardwood lumber from low-grade logs for use by the furniture industry. Low-, medium-, and high-grade red oak logs 13, 16, and 19 inches in diameter were rotary cut into 1/8" veneer. Ten veneers, defects repaired or unrepaired, were laminated with urea resin in decreasing order of quality (fig. 20) from surface (clear face) to center to form boards 1-1/4" in thickness.

Average specific gravity of the laminated lumber was 0.62, similar to that of solid red oak wood. Swelling in thickness (radial direction) and in width (tangential direction) and most of the strength properties of the product were also similar to that for solid wood. Shear parallel to grain at the radial surface was slightly less for the product compared with solid wood, perhaps because of veneer checks developed during peeling and drying. Improvement of this strength property has been achieved by the use of crossband, oriented at angles of 30 degrees or less between the grain of the crossband and the edge of the board. Crossbanding also reduced width swelling.

Several furniture manufacturers tested the product and reported that the strength, finishing and machining properties, except lathe turning, were satisfactory. Difficulty in lathe turning can be lessened by improved peeling, drying, and gluing, and by using narrow-rayed species. Easy handling due to uniformity in size and greater usable volume due to 100 percent clear-face cuttings are some of the expected advantages of this product.

Preliminary cost estimates have been made for a plant to manufacture laminated lumber from grade 3 red oak logs with a yearly production of 8,702,400 board feet, or 435,120 laminated boards 2' x 8' x 1-1/4" thick. The breakeven price has been estimated to be \$167.16 per thousand board feet, or \$3.35 per board.



Figure 20. Veneers of red oak logs are shown in decreasing order of quality: 1-Face; 2-Veneer next to face; 3-Third veneer; 4-Fourth veneer; and 5-Fifth or the innermost veneer. Mississippi State University, 3626.

UNIVERSITY OF MISSOURI, 165

Anatomy and properties of Missouri woods.

E. A. MCGINNES, JR.

Basic work on the nature of shake development in the oaks and black walnut has progressed to the point where the influence of time of injury (during growing season) is being investigated. The effects of June, November, and February "injury" dates, all some 20-years old, on wood formation are being evaluated in terms of anatomical and ultrastructure features. The species being studied is white oak. Intraincremental chemical analyses of the shake ring in a scarlet oak tree have been completed. The abnormal increment within which the ring shake was confined apparently formed as a result of external injury in the crown some 42 feet above stump height. Traumatic tissue formation was triggered along with an apparent resurgence of spring-like growth as indicated by production of earlywood-sized vessel formation in the center of the ring. The shake portion(s) of the annual increment was characterized by higher extractives content, higher lignin and methoxyl contents, lower holocellulose content, and lower DP of the holocellulose fraction compared with similar analyses of normal wood zones from a control increment.

STATE UNIVERSITY OF NEW YORK, 401-4-2

Formation, ultrastructure, and chemical composition on the xylem ray cells in conifers.

T. E. TIMELL

During the past year, research was completed on the cambial zone and the phloem associated with the formation of normal and compression woods of Norway spruce. The cambial zones, both dormant and active, were the same in the two types of wood. The parenchyma cells in the dormant phloem were also similar except that there appeared to be more starch in the compression phloem. The stimulus to form compression wood probably is received in the expanding cambial cells and not in the dividing or developing cells.

A second project involved the chemistry and structure of opposite wood, which is the wood produced in branches and leaning stems of conifers on the upper side, opposite to the compression wood. Opposite wood was found to be identical with normal wood in chemical composition but had more regularly arranged and angular tracheids. These tracheids also had an unusually thick, highly lignified S_3 layer. In almost all characteristics, normal conifer wood is intermediate between opposite wood and compression wood.

NORTH CAROLINA STATE UNIVERSITY, 4027

A fracture model for wood with localized defects.

R. G. PEARSON

Some justification exists for the simulation of knots and other local defects in structural lumber by artificial cracks so as to study their effects on strength in tension. Tests were made on matched pairs of southern yellow pine specimens. One specimen of each pair had a single knot and the other a short narrow slot cut perpendicular to the grain in a similar relative position to the knot. Results indicate that the theory of fracture mechanics should be a useful tool for studying the tensile strength of lumber.

Good estimates of the tensile strength of the specimens with knots were obtained from the appropriate equations of fracture mechanics, using estimates of the fracture toughness obtained from the matched slotted specimens and crack lengths based on the knot sizes. Equally satisfactory estimates were obtained for specimens with edge knots as for those with central knots, despite the much greater severity which edge defects are known to have on tensile strength.

OREGON STATE UNIVERSITY, F-879

Bonding mechanisms in bark composition boards.

J. D. WELLONS III

Processors of forest products are continuously seeking ways to utilize wood and bark residues at the mill site so that they may conserve the forest resource,



Figure 21. This scanning electron micrograph of Douglas-fir bark reveals the altered structure of a cork particle after it has been treated with solvent. Oregon State University, F-879.

increase the dollar return from raw material, and reduce pollution related to solid waste disposal. Utilization of bark from logs has major significance in this search.

Research underway is designed to aid in the production of new and improved bark composition boards through anatomical, physical, and chemical studies of Douglas-fir bark particles.

Because of the importance of cork in the cohesive bonding of bark particles, this fraction was studied. The cork fraction was treated with a variety of solvents. The amount of swelling and unfolding of the cork cell walls varied with the properties and temperature of the solvent used (fig. 21).

This information helped define the mechanisms for cohesive bonding of bark particles under optimum heat and pressure without adhesives. Self-bonding resulted primarily from thermoplastic flow and physical consolidation of cork particles. Chemical bonds were not evident and bark extractives were only a minor contributor to the self-bonding.

Information developed from this study will help determine what additives are needed to manufacture a bark particleboard that will perform satisfactorily in service.

PENNSYLVANIA STATE UNIVERSITY, 1925

Increasing the operating efficiency in forest products industries.

P. C. KERSAVAGE

The effect of sawing method on hardwood sawmill headrig operations was investigated. Gross time study data obtained from records of a sawmill monitoring system were statistically analysed. Analysis of variance indicated that the number of sawing and turning elements and the times spent in sawing and turning, along with total processing time per log, were significantly greater for grade sawing compared with live sawing. Loading and unloading times were statistically similar, whereas times per sawing and turning element were significantly greater for live sawing. Comparison of cherry lumber produced by each sawing method indicated major differences occurred in recovery of certain lumber grades. Live sawing decreased the percentage of Selects (24 to 16 percent) and increased the percentage of No. 2 Common (13 to 25 percent). However, cost analysis of three different studies indicated decreased recovery was more than compensated by increased productivity in live sawing and that it was also more profitable.

Detailed time studies of band sawing made from monitoring system records indicated more refinement in defining elements is possible using the recorded data, elemental times can be measured more precisely, and considerably more information is obtained, including the nature of delays and procedural variations. The monitoring system could also be used, either continuously or intermittently, for other purposes; such as determining power expended in sawing, evaluating saw blade performance and sawyer efficiency, and assessing debarking, edging, and trimming operations.

PENNSYLVANIA STATE UNIVERSITY, 1917

Effects of environmental variation on selected physical and chemical properties.

W. K. MURPHEY and R. C. BALDWIN

Two experiments are being conducted in this study. Effluent from a municipal sewage treatment plant was used to irrigate red pine and red oak trees. Physical and mechanical properties of the wood developed during the irrigation period were compared with wood grown prior to irrigation. This work is completed. Extractive content and amount of Klason lignin tests are being

conducted on the red oak wood. In the second experiment, cuttings of hybrid poplar are being grown in controlled nutrient solution. The objective of this research is to determine the effects of P and K on anatomy and chemical properties of the hybrid poplar.

Results to date suggest irrigation at 2 inches a week throughout the growing season on the canopy of red pine is detrimental. Spraying of 1 inch a week on the canopy or 2 inches a week on the undergrowth improved tracheid properties for pulp. Red oak responded positively to irrigation at 2 inches a week throughout the year. Increased growth, specific gravity, and latewood vessel element length were among those properties measured which improved. These changes improve the utilization of the species for pulp.

TEXAS A&M UNIVERSITY, 1650

Potential Formosan termite damage in Texas and an evaluation of control methods.

A. E. LUND

Over 300 laboratory colonies of Formosan termites Coptotermes formosanus were studied with respect to food-substrate moisture content, temperature requirements, commercial wood preservatives, and food preference and feeding habits. Test animals functioned most effectively at food-substrate moisture content levels of 10 - 15 percent and at 90°F. Commercial preservatives including creosote, pentachlorophenol, and chromated copper arsenate were tested and found effective against the Formosan termite when applied at AWPAs recommended ground contact retentions. Feeding preferences of Coptotermes formosanus were tested under both forced and choice conditions on 21 commercial wood species. Generally, the heaviest attack was sustained by western redcedar, southern yellow pine, red gum and ponderosa pine. Redwood, hickory and black gum were attacked moderately, and red spruce, yellow poplar and white pine were least preferred (fig. 22). These tests indicate that the Formosan termite will be able to thrive in all but the most arid regions of western Texas and is potentially hazardous to major commercial wood species unless the wood is treated to specified ground contact retentions with accepted commercial wood preservatives. Standard preservative treatments for the native Reticulitermes spp. should be effective against the Formosan termite if carefully administered. Other control measures such as soil poisons were not studied.

VIRGINIA POLYTECHNIC INSTITUTE, 636119

Accelerated seasoning of large-dimension wood products.

R. E. MARTIN and G. IFJU

Seasoning in this study was considered in terms of basic physical phenomena governing movement of moisture in wood. A theoretical approach to moisture movement was taken using mathematical models for describing the real situation in wood drying. Solutions of the diffusion equation, as given by Fick's law, with the aid of published coefficients were compared with experimental drying results. The diffusion equation with concentration-dependent coefficients can

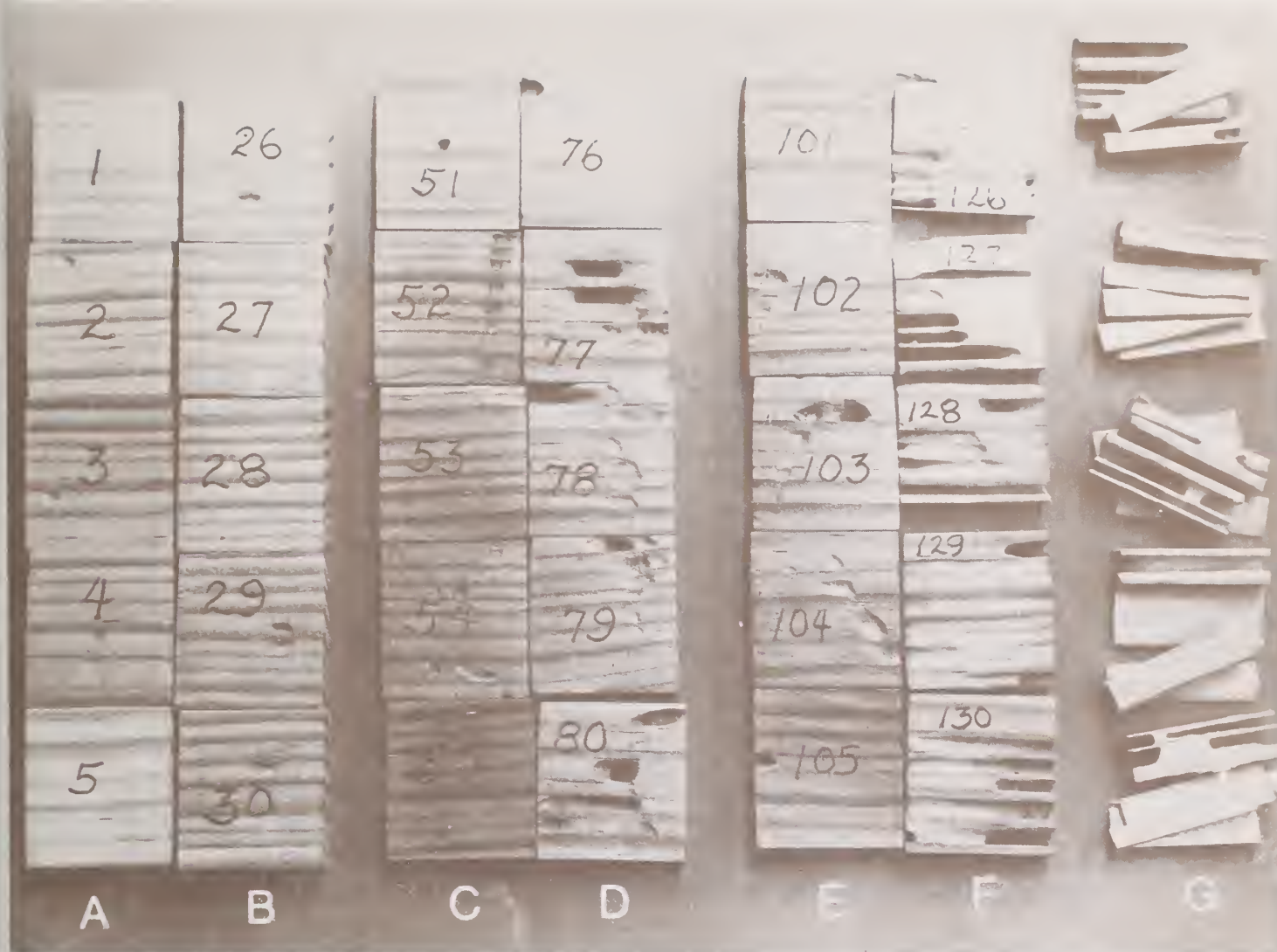


Figure 22. Shown are results of an attack by Formosan termites on Southern pine blocks that were treated with sodium arsenate (A & B), copper sulfate (C & D), potassium chromate (E & F). The last group of blocks (G) was not treated. Texas A&M University, 1960.

be solved using numerical methods in such a form as to be useful in predicting drying results. The Matano solution provided an acceptable method for measuring diffusion coefficients. These coefficients used in connection with the diffusion equation were found to provide good mathematical models for the quantitative explanation of drying processes in wood.

A second aspect of this study was investigating the effects of stress on moisture distribution in wood while graining or losing moisture. Bending stresses cause uneven moisture distribution such that the tension side of a wooden beam reaches a higher moisture content than does the compression side in a given relative humidity condition. Stresses thus were shown to have an effect in wood drying, especially stresses produced by the shrinkage of wood. These stresses should contribute significantly to seasoning of large-dimension wood products.

Distribution of aggregate rays in red alder.

A. F. NOSKOWIAK

The number and distribution of aggregate rays in the wood of red alder (Alnus rubra Bong.) is very sporadic; some pieces contain large numbers and others, none at all. Thus, difficulties arise in identifying the wood and irregularities of ray figure pattern occurring in furniture parts made from lumber blanks.

Objectives of this study are to determine patterns of occurrence and distribution of aggregate rays within trees and to ascertain the influence of geographic location upon those patterns.

Five trees encompassing the diameter range on each of five, 1/10th-acre plots located in western Washington will be felled and examined. All plots are on a high-quality site and at about the same altitude. Trees from four plots have been collected. The main bole of each tree is cut into 25 bolts of equal length. The number and position of aggregate rays on the cross sections at ground level and at the top of each bolt is recorded.

Analysis of two trees from one plot revealed that aggregate rays are virtually absent in juvenile wood and are present in only one or two quadrants of the bole near the base of the tree. Ray spacing in mature wood is quite variable. This distribution pattern, if repeated in trees yet to be analyzed, would seem to explain the sporadic occurrence of aggregate rays in red alder lumber.

WEST VIRGINIA UNIVERSITY, 3

Utilization of sprout black cherry.

C. B. KOCH

This research shows that a considerable quantity of clear, black cherry wood in short lengths can be sawed from trees too low in value to process on a long-log basis. The gross yield from 60 such trees, bucked into short bolts and sawed with a bolter saw, was 4 percent greater than the scaled log volume. Gross yield was increased an additional 30 percent by sawing tops and large branches. The net yield in furniture flat stock was about 80 percent of the gross yield, and over 50 percent of this was graded as select or better.

Increase in gross yield from log portions of trees was attributed to a reduction in effect of taper and crook or sweep by sawing short lengths. The high net yield resulted from removal of defects during bucking and from sawing parallel to the bark rather than the pith. Whether cuttings were obtained by cross-cutting first or ripping first made no difference as far as net yield and grade were concerned. Because of a low stumpage price and the yields obtainable, the conversion of such material into parts suitable for small furniture appears to offer considerable potential.

No problems were encountered in seasoning stem wood, even when lean was appreciable. In branches, however, the effect of tension wood was noticeable in both seasoning and machining. Such wood was found to have a higher than average cellulose to lignin ratio and an increase in supportive tissue. Eccentricity of pith was not closely related to location of tension wood.

UNIVERSITY OF WISCONSIN, 1518

Avoiding checks in wood and wood products.

H. J. KUBLER

A new method for drafting optimal kiln drying schedules for lumber of any wood species was developed. Optimal schedules facilitate fast drying without defects such as surface checks or cracks. The method is based on shrinkage and strain at fractures of wood in the direction of the growth rings. Lumber checks when its tensile strain from shrinkage reaches strain at fracture values. Both shrinkage and strain at fracture increase with temperatures. The drying temperature for green wood is at an optimum where the wood surface can have the lowest moisture content without tensile strain reaching a point of fracture. According to measured shrinkage and strain, this optimal temperature seems to be near 120°F for northern red oak and around 195°F for aspen. In drafting the schedule, relative humidity of the drying atmosphere is chosen in equilibrium with the lowest moisture content mentioned above. Later on in the drying process, when the inner layers of lumber shrink, the same principle is applied again to find proper drying conditions; again, strain from differential shrinkage should not reach a point of fracture. The new "Shrinkage-Strain-Control" method is expected to lead to improved kiln drying schedules for many wood species.

ADDITIONAL PROJECTS

ALABAMA - AUBURN UNIVERSITY, 914

Mineral composition of figured and unfigured wood.

H. O. BEALS and E. S. LYLE, JR.

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Logging costs and economic accessibility of interior Alaska forests.

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Wood machining.

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Chemistry and utilization of bark.

A. B. ANDERSON

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Heating methods in the drying of wood.

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Diameter shrinkage of logs in storage.

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Multicomponent binder systems for particleboard manufacture.

H. E. TROXELL and F. F. WANGAARD

COLORADO STATE UNIVERSITY, 338

Malodor-free alkaline pulping of wood.

H. A. SCHROEDEP and R. C. FRANCE

UNIVERSITY OF FLORIDA, 1575

Pulp mill waste utilization for bacterial production of cellulose and other by-products.

R. G. STANLEY

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Influence of wood characteristics on the processing and properties of reconstituted products.

J. T. RICE, R. H. PAGE,
and C. M. CHEN

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Unit fiber stress rings of Douglas-fir.

A. D. HOFSTPAND

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Grain angle and strength of Grand-fir.

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A problem analysis of precision thin sawing.

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High-pressure treatment of red oak and white oak.

C. S. WALTERS

SOUTHERN ILLINOIS UNIVERSITY, 69-R-23

Effect of moisture cycling upon dynamic strength properties of wet and dry process fiberboard.

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SOUTHERN ILLINOIS UNIVERSITY, 70-R-5

Fiber-tracheid characteristics in Ailanthus altissima Mill.

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Stresses in fabricated structural timbers and frames.

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Glued wood corner joints of high strength.

D. B. RICHARDS

UNIVERSITY OF KENTUCKY, 1028

Wood fiber mechanisms.

R. C. TANG

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Composite pole laminates.

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Liquid and gas permeability of wood as an indication of treatability with creosote and copper sulfate.

E. T. CHOONG and P. J. FOGG

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Maine wood properties and grades for product utilization.

J. E. SHOTTAFFER, T. J. CORCORAN,
and C. E. SHULER

UNIVERSITY OF MAINE, 5009

Anatomy and fundamental properties of Maine woods.

N. P. KUTSCHA, J. E. SHOTTAFFER,
and C. E. SHULER

UNIVERSITY OF MASSACHUSETTS, 3

Rheology of wood.

R. B. HOADLEY

UNIVERSITY OF MASSACHUSETTS, 4

Properties of wood from Northeastern tree species.

H. B. GATSLICK, W. W. RICE,
and W. S. McNAMARA

UNIVERSITY OF MICHIGAN, 20

Site quality and wood quality in upland hardwoods.

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MICHIGAN STATE UNIVERSITY, 1048

Measurement and analysis of hygroscopic dimensional changes of wood composite products.

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Characteristics and potential of freezing as pretreatment for accelerated drying of important species.

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Wood properties of Delta hardwoods.

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Efficiency lumber manufacture.

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Evaluation of sap-stain control chemicals and wood preservatives by respirometry.

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Variables affecting quality of preservative treatment of poles and piling.

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Exterior finishing systems for wood products from southern yellow pine.

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Pyrolysis of cellulose and related model compounds.

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Chemistry, distribution, and biosynthesis of flavanoids in wood.

F. SHAFIZADEH

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Wood drying stresses and improved kiln practice.

J. L. HILL

STATE UNIVERSITY OF NEW YORK, 401-3-12

Neutron activation analysis (NAA) of wood, treated wood and wood products.

J. A. MEYER and J. F. SIAU

STATE UNIVERSITY OF NEW YORK, 401-4-2

Formation, ultrastructure, and chemical composition of xylem ray cells in conifers.

T. E. TIMELL

NORTH CAROLINA STATE UNIVERSITY, 4005

Wood fiber properties and paper quality.

A. C. BAREFOOT and R. G. HITCHINGS

NORTH CAROLINA STATE UNIVERSITY, 4029

Isolation and characterization of cellulase lignin.

H. CHANG and E. B. COWLING

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Sulfur free pulping using oxygen and alkali.

J. S. GRATZL, H. CHANG,
and W. T. McKEAN

OREGON STATE UNIVERSITY, F-812

Electrical properties of wood below radio frequency.

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Environmental and genetic effects on pulping characteristics of Oregon woods.

W. J. BUBLITZ and M. D. McKIMMY

PENNSYLVANIA STATE UNIVERSITY, 1823

Rheology of wood cellulose in situ.

W. K. MURPHEY, F. C. BEALL,
and L. E. RISHEL

PENNSYLVANIA STATE UNIVERSITY, 1869

A thermogravimetric analysis of adhesive and wood fiber behavior.

F. C. BEALL, W. K. MURPHEY,
and G. A. ZIEGLER

PENNSYLVANIA STATE UNIVERSITY, 1988

Development of a method for press-drying dimensional stock.

F. C. BEALL

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Hardwood characteristics.

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Chemical utilization of southern yellow pine bark.

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VIRGINIA POLYTECHNIC INSTITUTE, 636160

Effects of steam treatment on the structure and properties of red oak wood.

G. IFJU

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Structure and physical-mechanical properties of eastern tree barks related to their utilization.

G. IFJU

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Stress wave attenuation as an indicator of wood strength.

R. F. PELLERIN

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Dynamic strain and piezoelectric effect in wood.

R. F. PELLERIN

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Minimizing deterioration of exposed structural wood members.

H. D. ERICKSON

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The formation and properties of particleboard using wood-polymer composites.

J. R. HAMILTON

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DEVELOPMENT OF MARKETS AND EFFICIENT MARKETING OF TIMBER AND RELATED PRODUCTS

Research Problem Area 502

Development of markets and efficient marketing of timber and related products may help to maintain the incomes and employment associated with the timber industry. Nonwood products have penetrated many traditional markets for wood materials in construction, manufacturing, shipping and other uses. Research to evaluate opportunities for market expansion through more efficient processing and marketing of timber products is essential to maintain and improve the competitive position of wood and wood and timber-related products.

MISSISSIPPI STATE UNIVERSITY, 615

Cost accounting for timber harvesting contractors.

R. R. FOIL

Mechanization of harvesting operations and some Federal labor requirements have brought about accounting burdens which are alien to most timber producers. High costs associated with the mechanized harvesting systems currently in use make it essential that a cost accounting system be developed that is structured to the needs of these producers.

Recognizing this need, researchers have been working with cooperating loggers to develop a computerized accounting system that provides data for management and at the same time satisfies tax and other governmental recordkeeping regulations.

The system which has been developed emphasizes cost factors leaving profit or loss computations to the individual logger. Information for the system requires the monthly input from the logger of two coded forms and initially one form for every piece of logging equipment. Variable costs associated with the operation and timber volume production will be recorded on the monthly input forms, while the initial equipment forms will be used in the calculation of fixed costs associated with owning machinery.

The amount of input provided is regulated by the logger and is reflected in the quality and utility of the feedback he receives. The system is flexible, however, and allows the logger to graduate from the very simple to more complex needs as the user gains experience and managerial skills.

From the data submitted, the computer program has the capability of developing summary tables reflecting all facets of the harvesting business. Monthly reports are issued that identify the costs associated with each month's production as well as comparing current costs with the preceding month's costs. Total yearly costs are also presented on monthly reports.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2538

Economic analysis of wood procurement systems.

W. L. McKILLOP

SOUTHERN ILLINOIS UNIVERSITY, 70-R-11

The influence of wood color and other physical characteristics on the value of black walnut veneer.

R. S. FERELL

UNIVERSITY OF KENTUCKY, 606

Economic structure and performance of the Kentucky sawmill industry.

D. H. GRAVES, J. C. REDMAN,
and L. MATHER

NORTH CAROLINA STATE UNIVERSITY, 4022

Wood residue production and feasibility of conversion to a saleable product.

D. H. J. STEENSEN and J. HEDGECOCK

UNIVERSITY OF VERMONT, 23

Disposition of bark and wood residues by primary wood processors in Vermont.

R. A. WHITMORE, JR.

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IMPROVEMENT OF GRADES AND STANDARDS OF FOREST PRODUCTS

Research Problem Area 512

Grades and standards describe the characteristics of a product so that producers and processors, and buyers and sellers can gauge product utility. Tree grades provide a means of more effectively valuing growing stock, thus assisting the producer to set specific goals for silvicultural practice and to obtain true value for stumpage. Log grades reduce the uncertainty in product transactions and permit segregation of logs for their highest use, to the benefit of both buyer and seller. Standards for processed forest products likewise assist buyers in obtaining product characteristics they desire and sellers in obtaining appropriate compensation for what they sell. Because wood is by nature a very heterogeneous material, the efficiency of the whole structure of wood markets depends to a large degree on the existence of accurate and understandable grades and standards.

UNIVERSITY OF CALIFORNIA, 2357

Marketability of veneer and plywood from young-growth California pines and redwood.

F. W. DICKENSON

Rotary veneer cutting characteristics of young-growth redwood and incense cedar have been examined. The best quality redwood veneer was produced using either a gap of 0.093 or 0.083 inch and a veneer bolt temperature in the 160-180°F range. The best quality veneer was produced from incense cedar using a gap of 0.095 inch and a bolt temperature in the range of 120 to 150°F.

A mill study indicated that young-growth redwood veneer produces plywood panels comparable to panels made from old-growth material and that there are no special merchandizing problems. In recent months, at least one commercial plywood operation has been using veneer from young-growth in its production.

While sapwood of incense cedar was found to produce good quality veneer, severe lathe checking of heartwood resulted in low veneer recovery. Also, the yield of face-quality veneer was found to be low. Results of a mill study indicate that because of the above factors, as well as the marked tendency of the dry veneer to split under normal handling procedures, the processing of incense cedar for plywood is a marginal operation at best.

Currently, young-growth ponderosa pine, sugar pine, and white fir are being investigated.

ADDITIONAL PROJECTS

SOUTHERN ILLINOIS UNIVERSITY, 72-R-30

Effect of moisture fluctuations on stress relaxation in hardwood.

A. A. MOSLEMI

UNIVERSITY OF KENTUCKY, 601

Improved hardwood log breakdown.

D. B. RICHARDS

WASHINGTON STATE UNIVERSITY, 1929

Factors affecting the vibrational parameters of structural lumber.

R. F. PELLERIN

SUPPLY DEMAND AND PRICE ANALYSIS --FOREST PRODUCTS

Research Problem Area 513

Improved forecasts of supply, demand, and prices of forest products are essential to more efficient and orderly planning for production and marketing. Individual producers, processing and marketing firms, and end users base decisions on information about the forecasts of future supply, demand, and price conditions. Sound public policy of forest conservation depends on such information. The forest supply industries need similar data on goods and services purchased by producers so that they may make orderly adjustments to prospective changes in supply, demand, and price of production inputs.

NEW MEXICO STATE UNIVERSITY, 8

Economics analysis of market opportunities for New Mexico forest mill by-products.

J. R. GRAY

Sawdust and bark are creating environmental problems in New Mexico. Costs of operating antipollution equipment in wigwam burners were 36 cents per ton in 1972 and \$3.44 per ton for piling or dumping. The potential demand in New Mexico was estimated at 23,000 tons of sawdust as bedding or litter and 130,000 tons as mulch. A survey of over half the potential users indicated only 1,000 tons of sawdust and 350 tons of bark were being used.

Bark prices paid by wholesalers were less than those paid for other decorative covers while sawdust prices per unit of bulk were from two to three times cheaper than all other mulches except straw. Potentially unique uses for both sawdust and bark were as cover for highway right-of-ways, trails, cemeteries, and play areas.

VIRGINIA POLYTECHNIC INSTITUTE, 636118

An economic model for Southern industrial forest regulation.

E. F. THOMPSON

During this project's 5-year life, various approaches were taken in achieving the primary objective of increased decisionmaking efficiency. Early efforts were devoted to establishing a theoretical base for forest regulation in general. First, available forest regulation models were questioned and models capable of explicitly recognizing uncertainty were thought to be more appropriate.

Second, we considered the less theoretical problem of integrating industrial property regulation and open-market wood purchases to achieve least-cost wood procurement schedules. This phase reflected the preceding theoretical work in that initial least-cost schedules did not consider uncertainty. Subsequent schedules were modified to contain probabilistic components in an effort to reflect the uncertainty inherent in industrial wood procurement.

The final phase of the project was concerned with achieving timber regulation compatible with specified nontimber objectives. That is, this phase was concerned with multiple-use forestry. To implement this phase, data from a Maryland State Forest were used in a case study approach. A model was constructed which evaluated the effect, in terms of timber foregone, of various levels of wildlife management intensity. The model appears quite promising and a new project to continue the research has been initiated.

ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2505

The role of oligopsony and monopoly in markets for publicly owned timber in California.

H. J. VAUX

UNIVERSITY OF MARYLAND, A-18-BF

Economic analysis of the pine forest resources on Maryland's Eastern Shore.

I. W. HARDIE

TEXAS A&M UNIVERSITY, 1976

Recreation and forestry on small forest ownerships in east Texas.

R. L. BURY and J. R. WATERS

UNIVERSITY OF WASHINGTON, 19

Structural change in the forest products industries of the Pacific Northwest.

T. R. WAGGENER

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Recreation attitudes as related to forest and recreation management policies on small forest ownerships in east Texas. Texas A&M University. Dissertation. 1972.

HOUSING

Research Problem Area 801

Housing, as individual units and collectively, has a significant impact on the quality of rural living. Tremendous opportunities exist for research to reveal effective, economical procedures and materials for renovating and modernizing existing houses as well as in design and development of new housing.

Roof Loads

D.L. = 10 psf (479 N/m²)

L.L. = 25 psf (1197 N/m²)

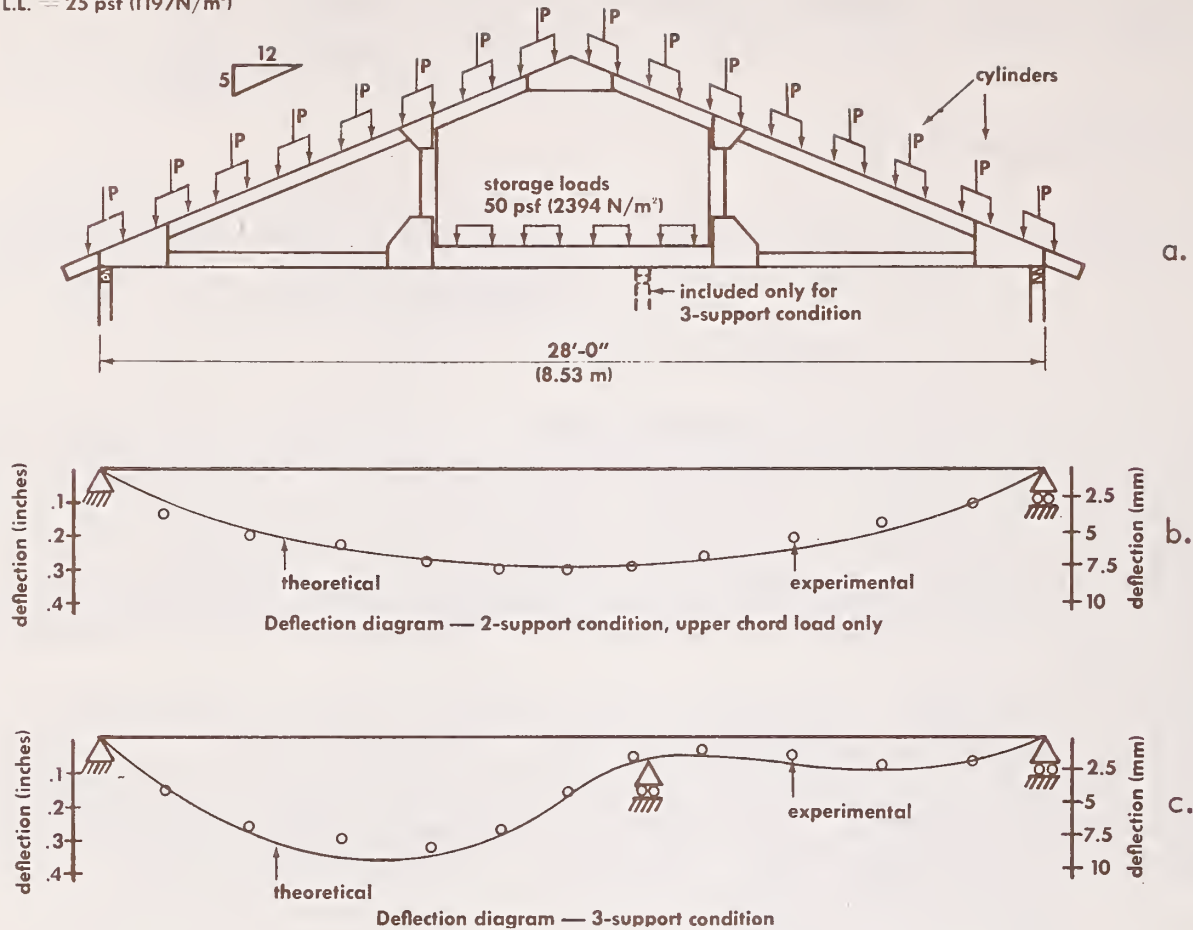


Figure 23. A full-scale attic storage frame was test loaded, supported by the outer walls only (top diagram). An inner support was added (middle diagram). A partially yielding center support was added (bottom diagram), and a comparison was made of theoretical and experimental values. Small circles represent actual deformation of the lower frame member--at 11 measurement stations. The solid lines predict information using the Purdue Plane Structures Analyzer. Indiana-Purdue University, 1353.

INDIANA-PURDUE UNIVERSITY, 1353

Analytical design of trussed rafters.

A. K. SUDDARTH

The Purdue Plane Structures Analyzer (PPSA), developed as a computerized system in previous stages of this project, has been employed in further work to create wood engineering improvements particularly applicable in light-frame construction. This building domain includes dwellings which are in short supply now, and it presents increasingly critical problems as world populations rise and resources are depleted. Increased efficiency through better engineering can extend available supplies and, at the same time, provide better houses. Specific action toward such a goal was the investigation of the value of the PPSA in interpreting the mechanical test performance of structural elements relative to their behavior in composite designs (fig. 23). The results

indicated the potential of increasing the applicability of fewer costly and time-consuming performance tests to an almost limitless number of prototype variations. Each innovative wood structural design has required individual tests in the past and applying this new tool will open the way to more progress by multiplying the value of each test. Research activities include automation of element performance tests by using the Agricultural Experiment Station's new MIRACLE data acquisition system. Costs of performance testing will be reduced further and statistical methods for more efficiency in the design process can be developed.

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Increasing the application efficiency of performance tests with analytic procedures. Washington, D. C. National Bureau of Standards Special Publication 361. Vol. 1. pp. 535-543. 1972.

FOREST WATERSHEDS, SOILS, POLLUTION

Clean water, clean air, and productive soils are our most precious physical resources. However, forest and range watersheds often depend on vegetative cover to maintain their rather fragile status. Faulty decisions in managing these lands can result in chain-reaction damage to soil and water and to the capacity to produce anything of value. The watershed systems of our country usually have their origins in forested lands, so sound management must start there. Research is now progressing to assure high-quality water, coupled with dependable yield. Another hope to improve the quality of air, soil, and water lies in research to develop sound forest land use planning.

A new and positive approach to the disposal of municipal sewer sludge and cannery wastes involves research on the effect of spreading these wastes on forested watersheds. Several new studies provide preliminary evidence that the forest floor and soil have the ability to naturally absorb and utilize the wastes and release pure water. The trees themselves increase in volume growth as a result of the fertilization process. Forest soil surveys are underway to determine what type of soils are best adapted to sludge treatment.

APPRAISAL OF SOIL RESOURCES

Research Problem Area 101

Agricultural agencies appraise the Nation's soil resources through soil classification and mapping the classified soil types. Research in support of soil mapping is concerned with identifying the parameters to be measured, including the correlation of soil map information with the use to be made of

the data (for example, crop production, housing developments, zoning), and the development of effective and economic ways of reporting the results.

In recent years, the use of these findings has extended far beyond that made by farmers and ranchers. For example, sanitarians and home builders are using the information for judging the capacity of soils to absorb septic tank effluent; architects and developers use the information for site evaluation and foundation design; and urban planners and other public officials use soil surveys for both general and operational planning of land use in rapidly expanding areas. Soil surveys can also be used to show soil characteristics such as susceptibility to frost heave or slippage, depth to water table, depth to rock or other impermeable barriers, bearing strength, flood hazard, and soil erosion potential which affect suitability of a site for specific uses.

OKLAHOMA STATE UNIVERSITY, 1513

Surface geology-soil relationships in western Gulf Coastal Plain and up-slope areas.

T. H. SILKER

Southern pine and associated hardwood distribution often shows a disjunct pattern that coincides with the disjunct pattern of podzolic soils (Psammets, Alfisols, and Ultisols). Forest plants in the Coastal Plain are considered to be dependent variables responding to favorable or discrete edaphic environments controlled by fluvial deposits, rather than independent variables that have helped weather soils in situ from variable rock strata.

Soil horizon samples from 25 upland plots, including three locations on the Citronelle Formation and four pits under "lost-pine islands" extending to Bastrop, Tex., are being processed for physical and mineral status. Preliminary trends for a common Susquehanna-like soil sampled shows the following. Soils above the Citronelle Formation have a fluvial history (confirming the status reported on the 1960 U.S. Geological Atlas). Other upslope soils have a like lithology and fluvial nature. All soil profiles show a marked discontinuity with the underlying bedrock that varies from Pennsylvanian sandstone and shale: Cretaceous limestone, marl or chalk; Eocene mudstone or sandstone; and Miocene sandstone or calcic clay. Washed gravel is commonly concentrated in the A₁ - A₂ horizons and again just above bedrock. No gravel is found in the bedrock. The gravel-sand mixture at the surface suggests it was a last-stage fluvial deposit. Moreover, the depth and texture of this strata have been key factors controlling moisture storage and retention capacity and therefore the ecosystem framework; that is, the distribution and function of certain pine and hardwood associations.

ADDITIONAL PROJECTS

UNIVERSITY OF ALASKA, 2

Nutrient cycles in selected interior of Alaska forest types.

K. VAN CLEVE

UNIVERSITY OF ALASKA, 270-0545

Relationships among vegetation, ground ice, and disturbances on north-facing slopes in the Fairbanks.

B. J. NEILAND

UNIVERSITY OF ILLINOIS, 55-0311

Soil-site relationship in northern Illinois.

H. FOX and A. R. GILMORE

OKLAHOMA STATE UNIVERSITY, 1512

Disjunct forest communities in Coastal Plain province: geologic-pedologic-biologic relationships.

T. H. SILKER

PUBLICATIONS

BARNEY, RICHARD J. and KEITH VAN CLEVE

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OLIVER, LOLA K.

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VAN CLEVE, KEITH

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VAN CLEVE, KEITH

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VAN CLEVE, KEITH and LESLIE A. VIERECK

Distribution of selected chemical elements in even-aged older (Alnus) ecosystems near Fairbanks, Alaska. Arctic and Alpine Research. Vol. 3. 1972.

SOIL, PLANT, WATER NUTRIENT RELATIONSHIPS

Research Problem Area 102

This problem area is concerned with the chemical and physical nature of interrelationships among soils, plants, water, and nutrients. The objective is to maintain or restore the inherent production capability of soils.

UNIVERSITY OF ARIZONA, 4168-19

Nitrogen and carbon balances in forest and range ecosystems in Arizona.

J. O. KLEMMEDSON

Results from a major study of this project may be useful in developing a quantitative model of nitrogen and carbon cycles, and in making management decisions for ponderosa pine forests of Arizona. Although the tree ecosystems studied (stands of dense sapling and pole-sized pine) contain ten times as much vegetal material as adjacent Arizona fescue-mountain muhly grassland parks, they are similar in quantity of total N. However, the distribution of N in the two systems is quite different. Soil contains 80 percent of the N in tree systems and 95 percent of that in grass systems. The large amount of N contained in the surface 15 cm of soil in the grass ecosystems compared with that for tree ecosystems (a rather atypical condition) offsets the large amount of N tied up in standing vegetation of the pine systems.

The C regime differs from that of N, both in amount and distribution of C. Tree ecosystems contained over twice as much C as the grass systems and the distribution pattern of C was distinctly different in the two systems.

Fifty-six percent of the C in tree systems was tied up in vegetal material as opposed to only 10 percent for grass systems.

Soil parent material significantly affected the amount of N in the ecosystems. The litter and soil components of ecosystems formed from andesite, basalt, and limestone contained a relatively large amount of N compared with those from ecosystems formed from rhyolite. In ecosystems formed on basalt, a grass biota was associated with significantly more N in the ecosystem than a tree biota. On other parent materials, biota did not affect amount of total N in the ecosystem. Because litter and soil are the largest pools of N in these systems, these components of the ecosystem should probably receive special attention in management schemes.

UNIVERSITY OF ILLINOIS, 308

Dynamics of soil microbiology and fertility during secondary succession.

G. L. ROLFE

In the prairie-forest border area of east-central Illinois, dark-colored and light-colored soils of prairie and forest origin occur in close proximity. Depending upon site conditions, prairie soils that have been invaded by trees may show minimal morphological changes even after 100 or more years of forest occupancy. However, subtle chemical changes may occur relatively early as shown by studies that compared the forms of nitrogen in the surface of Flanagan silt loam (a fine, montmorillonitic, Aquic Argiudoll) that was afforested 20 years ago with soil that had been under sod cover for an equal length of time. Greatest differences occurred under two coniferous species, red pine and Japanese larch, where the amount of exchangeable and easily soluble N was significantly greater than under the sod cover. In contrast, the soil under two hardwood species, basswood and yellow poplar, has significantly less of these forms of N than either of the other cover types. Total N was also greatest under the conifers.

No apparent changes were noted in organic matter content, exchangeable cations, or bulk density, changes that might be expected to occur relatively soon under forest occupancy. Subtle changes, such as in the forms of soil N, are precursors to developments that occur with time, and result in the light-colored soils that form under forest cover. Based on these limited data, such changes might well proceed more rapidly under conifers than under mesic hardwoods.

PENNSYLVANIA STATE UNIVERSITY, 1745

Revegetation of highly adverse sites created by coal mining.

R. J. HUTNIK

Plant growth on coal refuse is limited by: (1) lack of nutrients, especially N and P; (2) toxic concentrations of acid, Al, or Fe; (3) surface temperatures which may exceed 70 C° and stay above 50 C° for over 6 hours; and (4) dry surface layers. The effects of lime, fertilizer, and mycorrhizae on growth of Pinus resinosa and Betula pendula in coal refuse of three toxicities (mean pH's: A-2.6, B-3.4, C-4.8) were studied in the greenhouse. In refuse A, lime was essential and mycorrhizae was ineffectual. Fertilizer was significant

only when Pisolithus tinctorius--but not Cenococcum graniforme--was involved. Neither fungus affected growth of B. pendula. Lime and especially fertilizer increased growth in refuse B and C.

Ameliorative treatments of refuse A and B were studied in the greenhouse, using the same tree species. Seedlings survived in refuse A only if they received either a soil covering or an acidity treatment; without the latter, roots did not cross the soil-refuse interface. On refuse B, the soil covering decreased growth. Flyash and limestone raised pH equally well, but seedling growth was better with flyash on refuse B, and with limestone on refuse A. Limestone encouraged growth more on refuse A because flyash has a high salt content. Growth response to both N and P fertilization was significant, as was the interaction of N and P. Current field studies involve analysis of the effects of various mulches, used in combination with lime and fertilizer, on the microclimate of coal silt-basins and on seedling growth in such basins.

ADDITIONAL PROJECTS

UNIVERSITY OF ARKANSAS, 610

Use alternatives on forest lands of Ozark upland region of north Arkansas.

H. A. HOLT

UNIVERSITY OF FLORIDA, 1250

Water control for production of southern pines.

C. M. KAUFMAN, R. E. CHOATE, and
W. L. PRITCHETT

UNIVERSITY OF GEORGIA, 23

Water soil and plant relationships in forest resource management.

J. T. MAY and K. STEINBECK

UNIVERSITY OF ILLINOIS, 55-0362

Effect of moisture stress on monoterpenes in loblolly pine.

A. R. GILMORE

UNIVERSITY OF KENTUCKY, 199

Edaphologically important physical and chemical properties of major forest soils in Kentucky.

R. L. BLEVINS and E. H. WHITE

UNIVERSITY OF MAINE, 5008

Fertilization of spruce-fir sites in Maine.

C. E. SCHOMAKER, R. A. STRUCHTEMEYER,
and E. L. GIDDINGS

WEST VIRGINIA UNIVERSITY, 6

Microclimate modifications affecting reforestation of surface-mined lands.

R. LEE

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CONSERVATION AND EFFICIENT USE OF WATER

Research Problem Area 105

Virtually all of the Nation's water supply arrives as precipitation on the land. Seventy percent of this supply is lost through evaporation and transpiration. The remaining 30 percent is subject to increasing competition among agricultural, industrial, and domestic users. Increased efficiency in collecting, storing, conveying, using, and reusing available supplies becomes essential.

UNIVERSITY OF KENTUCKY, 603

Effects of man's use on forested watershed ecosystems.

E. H. WHITE and D. D. HOOK

The Eastern Coalfield Region is the primary watershed for over half the State of Kentucky. Since approximately 90 percent of the water used in Kentucky is in the form of surface water, land-use practices in the headwater areas can greatly affect the quality of this vital resource.

Three adjacent watersheds are being monitored on Robinson Forest in Eastern Kentucky to provide baseline data on the quality of water draining from relatively undisturbed watersheds.

Because baseline data on water quality for undisturbed forested watersheds in Eastern Kentucky are virtually nonexistent in the literature, results from the monitored watersheds will prove invaluable in evaluating water quality from managed forest lands. These findings will also help in the evaluation of the effectiveness of amelioration and reclamation efforts in returning disrupted ecosystems towards normality.

Ranges and means were derived from approximately 1500 analyses of the water quality parameters measured for the water year October 1971-September 1972. These ranges and means substantiate the high quality of water flowing from the watersheds. All values are well below U.S. Public Health Service permissible criteria for drinking water standards.

ADDITIONAL PROJECTS

UNIVERSITY OF GEORGIA, 24

Interrelations of forest, water and climate.

J. D. HEWLETT and W. L. NUTTER

TEXAS A&M UNIVERSITY, 1649

Field investigation of water stress and growth in loblolly pine.

D. M. MOEHRING

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WATERSHED PROTECTION AND MANAGEMENT

Research Problem Area 107

Nearly 12,000 agricultural and forested watersheds in the country are in the size category commonly encompassed in developments under the Watershed Protection and Flood Prevention Act, the Small Reclamation Projects Act, and similar programs. These watersheds include the cropland of the United States as well as the range and forest lands. Many of the watersheds need one or more of the following flood prevention systems: sediment control, wind and water erosion control, and control through improved management for water yield and quality.

Sediment control is needed to prevent unwanted deposition of eroded material in reservoirs, harbors, stream channels, and streets and highways, or on flood-plain lands. Sediment in streams damages recreational values and must be removed from domestic and industrial water supplies. Erosion control is needed to protect the productive capacity of the land.

UTAH STATE UNIVERSITY, 777

Water balances in intermountain stands of Englemann spruce-subalpine fir.

G. E. HART

Four half-acre plots were established in an all-aged, over-mature spruce-fir stand in north central Utah at an elevation of 2600 meters. At each plot, 15 to 20 neutron-probe access tubes were installed in the soil up to 2 meters in depth. Weather factors were recorded at a centrally located station, and soil water depletion was monitored from late June to September. A corollary study was conducted 2 years of the 3-year period of the main study to determine the nature of water deficits in the soil-tree-atmosphere system. Thermocouple psychrometers and a pressure chamber were used. Tree water potential was measured by implanted psychrometers (fig. 24).

Findings of this project indicate that soil water is mainly used in the first meter of soil. Water contents below 1 meter remained above the wilting point percentage. Based on 3 years' data, soil water loss on the plots followed a consistent pattern. Depletion averaged 28 cm (from 66 to 38 cm).

Twenty-three intervals (about every 2 weeks) of soil water depletion were analyzed. Through a "paired plot" approach, two of the four plots have been designated as control and two as treatment, and statistical evaluation of this calibration is being determined. Clearcut of the treatment plots will follow at the end of the fifth year. Results so far indicate that small water savings will result when vegetation is completely removed. The effect of increased snowpack as a result of such removal will also be studied.



Figure 24. Instruments used to measure the internal water potential of a tree. (Note the psychrometer installed in the tree trunk.) Utah State University, 777.

Internal water potential (water deficit) of mature spruce trees varied markedly on a diurnal and seasonal basis. Mathematical equations were derived which explain 81 percent of hourly and 72 percent of daily variation in water potential-variables are solar radiation, wind, and vapor pressure deficit. Transpiration, inferred from internal water potential, was highly correlated with atmospheric but not with soil variables. The usefulness of thermocouple psychrometers for measuring water potentials in field situations was demonstrated.

UNIVERSITY OF MONTANA, 3001

Ecosystem study of the Elk Creek drainage in western Montana.

L.K. FORCIER and R. F. WAMBACH

The Lubrecht Ecosystem Project is a long-term interdisciplinary study designed to ascertain the safe limits of forest manipulation in the Northern Rocky Mountain Region. The intensive phase of the study, which is being conducted on the Lubrecht Experimental Forest near Missoula, Montana, utilizes the small watershed approach to ecosystem analysis (fig. 25). The biological, chemical, geological and hydrologic similarity of a series of watersheds, each less than 40 hectares, will be established. Several of these watersheds will then be subjected to management practices which are projected to be the ones most commonly used in the region during the future. Changes in the manipulated ecosystems' nutrient and energy regimes, as well as in their biologic parameters,



Figure 25. Installations for analysis of a watershed ecosystem.
University of Montana, 3001.

will be compared with such changes in control watersheds. Ultimately, these changes will be evaluated within the political and economic framework of the region.

Two control watersheds, one of 13 hectares with a south aspect and one of 34 hectares with a north aspect, have been surveyed and gridded into contiguous 50 m x 50 m units. Surveys of the trees, shrubs, and herbaceous layer of the control watersheds have been completed. Additionally, phenological studies necessary for understanding nutrient cycling and energy flow processes are underway.

A census has been made of the small mammal and breeding bird populations on the research area. Next summer, a special effort will be made to determine the effect that forest structure and, hence, aspects of forest management, have on bird diversity. Rates of litter decomposition and mineralization are being determined, as are the habitat requirements and substrate colonization rates of the area's aquatic invertebrates.

Emergency revegetation to rehabilitate watersheds denuded by wildfire.

J. R. NELSON

This study was initiated in September 1970, following two catastrophic fire storms which burned large range and timber tracts in northern and central Washington. The study contains three phases: (1) Study of factors which affect germination and establishment of broadcast seedlings on wildburn areas, (2) evaluation of suitability of various native and introduced grasses and legumes for use in wildfire rehabilitation, and (3) study of various fire intensity criteria and their usefulness in evaluating fire damage to understory vegetation and determining the necessity for rehabilitation through artificial reseeding.

Results to date suggest that few problems exist which prevent successful reseeding in burned-over forested areas. However, present policies of State and Federal land management agencies are to reseed only the most severely burned areas with steep terrain; these policies are inadequate. Using new fire-intensity criteria--for example, height of char on fire-killed trees--supplemented with conventional criteria, the land manager can predict natural understory recovery, and he can therefore determine the necessity for reseeding, to a high level of statistical reliability.

Reseeding efforts in the past on burned sagebrush-grass and depleted bunchgrass ranges have generally not been successful because of (1) competition from weedy annuals, (2) seed depredation by birds and rodents, and (3) offsite planting. Results of this study indicate that plant species with small seeds are best adapted for surface germination and they are least susceptible to bird and rodent depredation. The greatest success in reseeding low elevational burned areas has involved a simple technique. In late winter or spring, a suitable contact herbicide is applied for annual weed control. This application is followed by an aerial application of an adapted small-seeded species, such as Sherman big bluegrass (Poa ampla). Another effective technique is removal of litter by wildfire, which encourages complete germination of annual weed seed, primarily cheatgrass (Bromus tectorum), and thereby enhances the effectiveness of herbicide treatment. This technique has been tested six times in 3 years and has been generally successful each time.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 2016-4168-017

Snow water yield from conifer forest.

D. B. THORUD

UNIVERSITY OF CALIFORNIA, 2751

Impact of urbanization on natural ecosystems in the coast ranges of California.

J. R. McBRIDE

COLORADO STATE UNIVERSITY, 321

Water yields from shallow mountain soils in relation to forest cover.

E. W. MOGREN and H. L. TELLER

CONNECTICUT AGRICULTURAL EXPERIMENT STATION - NEW HAVEN, 415

Waste water renovation potential of forest soils predicted by their chemical and physical properties.

D. E. HILL and C. R. FRINK

UNIVERSITY OF MARYLAND, BO-1

Forest buffer strips in controlling animal waste runoff into streams.

D. F. BEZDICEK, J. E. FOSS, and
N. A. CLARK

UNIVERSITY OF MASSACHUSETTS, 2

Evapotranspiration, run-off, storage, and drainage characteristics of water from forest soils.

D. L. MADER and W. P. MacCONNELL

UNIVERSITY OF MISSOURI, 163

Forest hydrology of small Karst watersheds in the Missouri Ozarks.

C. D. SETTERGREN

UNIVERSITY OF NEVADA, 675

Water retention and movement in snowpacks on the east slopes of the Sierra Nevada.

M. B. SULAHRIA, J. H. HUMPHREY,
C. M. SKAU, and R. O. MEEUWIG

STATE UNIVERSITY OF NEW YORK, 107-0-6

Watershed model studies.

P. E. BLACK

PENNSYLVANIA STATE UNIVERSITY, 1495

Forest cover and timber harvesting methods related to streamflow.

W. E. SOPPER, R. E. MELTON, and
P. W. FLETCHER

PENNSYLVANIA STATE UNIVERSITY, 1991

Effects of forest cover and clearcutting on the snow hydrology of small watersheds.

D. R. DEWALLE and J. A. LYNCH

WASHINGTON STATE UNIVERSITY, 16

Elevation-frequency analysis of cloud-engulfed forests in mountains.

D. R. SATTERLUND

WASHINGTON STATE UNIVERSITY, 1925

Ecologic characteristics of elk sedge (Carex geyeri Boott.) for erosion control.

B. F. ROCHE, JR.

UNIVERSITY OF WASHINGTON, 20

Quantity measurement of snow melt water as related to runoff.

D. D. WOOLDRIDGE and S. P. GESSEL

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PROTECTION OF PLANTS, ANIMALS AND MAN FROM HARMFUL EFFECTS OF POLLUTION

Research Problem Area 214

Pesticides, salts, sewage, cannery, textile, and animal wastes are generally considered objectionable when they occur as pollutants. Under some conditions, they may be detrimental or cause effects detrimental to specific plants or animals.

Air pollutants such as sulfur dioxide, ethylene, and fluorides have long been recognized as being harmful to vegetation. Recently, increasing importance has also been attached to photochemical air pollution. Examples of damage to plants from pollution are: Fluoride damage to corn, citrus, trees, and flowers; ethylene damage to cotton and orchids; and ozone damage to cotton, grapes, tobacco, and trees.

Fluorides cause a serious malady in cattle known as fluorosis. Laboratory experiments with animals show that certain irritants common in polluted air can increase susceptibility to respiratory infection and they can increase mortality.

Pollutants which affect plants and animals may also affect man. Smog may cause eye irritation and increase the severity of respiratory ailments. Air-borne allergens, such as pollens, cause suffering to people susceptible to these allergens.

ADDITIONAL PROJECTS

COLORADO STATE UNIVERSITY, 326

The effect of rainfall acidity on coniferous trees.

W. E. MARLATT and W. D. STRIFFLER

UNIVERSITY OF CONNECTICUT, 440

The effect of some heavy metal pollutants on ectomycorrhizae.

D. B. SCHROEDER

LOUISIANA TECH UNIVERSITY, 7

Responses of selected southern tree species to specific environmental contaminants.

H. E. GARRETT

UNIVERSITY OF MONTANA, 3004

Effects of hydrogen fluoride on pollen viability in coniferous species.

C. C. GORDON

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ALLEVIATION OF SOIL, WATER AND AIR POLLUTION AND DISPOSAL OF WASTES

Research Problem Area 901

Soil, water, and air are being polluted with a variety of substances, both inorganic and organic. Some of the more apparent contaminants are organic pesticides, radionuclides in fertilizers, growth regulating chemicals, animal and crop wastes, mulching materials, pathogenic microorganisms, heavy metals, salts used on roads for de-icing, lead from fuel combustion, allergens, and radioactive fallout. Agricultural research must be primarily concerned with alleviating pollution initiated by agricultural and forestry practices.

Retention mechanisms in paper machine systems.

K. W. BRITT

In the manufacture of paper, a suspension of fibers, fiber fragments, and other fine particles (such as filler pigments) flows out on a moving screen. On this screen is deposited a mat that ultimately becomes the sheet of paper. A stream of water (filtrate) flows through the screen and carries with it a large proportion of the fine particles. Because cleaning showers and sprays must be used continuously at various points on the paper machine, there is always an excess of white water in the filtrate. This white water is recycled with new pulp, but the recovery and retention of the fines component of the furnish is costly and often unsatisfactory.

To study the influence of chemical and physical condition on retention under controlled conditions in the laboratory, it is essential to have an apparatus that will closely simulate the conditions prevailing in sheet formation. Such an apparatus was developed as part of the project (fig. 26).

A sample of paper stock is placed in the jar, which has a screen bottom. The jar is drained under selected degrees of turbulence produced by a speed-controlled stirrer. The amount of fines retained by the fiber in the paper stock is determined by the difference of this amount from the number of fines coming through with the filtrate. Under proper conditions, all the fines can be retained--even with severe turbulence.

This apparatus has been useful in the discovery of dramatically improved retention, and the effectiveness of these methods have been demonstrated on the paper machine in the pilot plant of Syracuse University's College of Environmental Science and Forestry.



Figure 26. This apparatus closely simulates the conditions prevailing in the formation of sheets of paper. State University of New York, 901-0-8.

ADDITIONAL PROJECTS

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3210

Effect of pulp residual hemicelluloses on cyclic dried paper strength.

B. C. H. SUN and G. A. HESTERBERG

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3313

Use of bacterium desulfovibrio to reduce pollution from pulp mill sulfite wastes.

M. F. JURGENSEN

STATE UNIVERSITY OF NEW YORK, 901-0-3

Fertilization - water quality: a review, analysis and evaluation.

A. L. LEAF

NORTH CAROLINA STATE UNIVERSITY, 4028

Water reuse in pulp and paper manufacturing.

C. N. ROGERS

TEXAS - STEPHEN F. AUSTIN STATE UNIVERSITY, 5

Land disposal of pulp mill effluent.

K. G. WATTERSTON

DEVELOPMENT OF FOREST, RANGE, WILDLIFE, AND FISHERIES HABITAT

In an age of changing land use patterns and practices, many problems exist for the land manager as well as for game and wildlife species. Our wildlife populations depend primarily on naturally occurring food and cover for their survival. As the human population increases, natural habitats of wildlife are replaced by homes, factories, and highways. Now is the time to consider the alternatives for man and wildlife within specific ecosystems. Many people who enjoy wildlife near their homes are increasingly concerned with the well-being of other creatures than game animals. Wildlife research in the past was concerned primarily with the harvest of game species. Visual observation of wildlife in its natural habitat is becoming more important as our urban population learns to appreciate the recreational value of animal and bird watching and photography. Continued studies of game biology and ecology will provide data for the wildlife specialist who hopes to blend the needs of people, animals, and forestry into a reasonable and balanced whole.

IMPROVEMENT OF RANGE RESOURCES

Research Problem Area 112

Range management research seeks to maintain and to improve the forage-producing capacity of rangelands. Native range in the United States includes over 900 million acres. It represents a continuum of sites and potential of productivity from the deserts of the Southwest to the prairies of the Midwest and from the sea-level grasslands of Florida to the alpine herblands of the high Rockies. Rangelands are important as a source of feed for beef cattle and sheep, in watershed protection, soil stabilization, wildlife habitat, and recreation.

ADDITIONAL PROJECTS

NORTHERN ARIZONA UNIVERSITY, 5

Range forage on parks in ponderosa pine.

L. D. LOVE

UNIVERSITY OF CALIFORNIA, 2500

Ecological adjustments of range plant populations to use and environment.

H. F. HEADY

UNIVERSITY OF FLORIDA, 1568

Management and use of selected forested ranges.

L. D. WHITE

UNIVERSITY OF IDAHO, 12

Effects of livestock trampling on plant growth and forage productivity.

L. A. SHARP

UNIVERSITY OF IDAHO, 18

Prescribed burning influences on the forage value of key big game browse species.

K. E. HUNGERFORD

NORTH DAKOTA STATE UNIVERSITY, 9-001

Growth and production of deer browse species in the badlands of western North Dakota.

H. GOETZ and W. C. WHITMAN

SOUTH DAKOTA STATE UNIVERSITY, 561

Tree encroachment into Black Hills grassland: ecology and management options.

F. R. GARTNER, W. W. THOMPSON,
and E. M. WHITE

SOUTH DAKOTA STATE UNIVERSITY, 627

Determination of soil properties causing ecological selection of range and pasture plant species.

E. M. WHITE

UTAH STATE UNIVERSITY, 670

Range Plant foliage removal effects on soil moisture regime.

C. B. COLTHARP

WASHINGTON STATE UNIVERSITY, 121

Ecological characteristics of yellow starthistle (Centarurea solstitialis L.) as control information.

B. F. ROCHE

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FISH AND OTHER MARINE LIFE, FUR-BEARING ANIMALS, AND OTHER WILDLIFE

Research Problem Area 904

Research on wildlife, fur-bearing animals, and fish and other marine life is needed to meet the ever-growing demands of hunters, trappers, and fishermen; to develop improved production of farm-reared fish and fur-bearing animals; and to assure continuing supplies of marine life for food and other purposes.

To maintain and increase the supply of wildlife, fish, and other marine life, it is essential to know how to maintain and enhance their habitat and it is essential to determine the biological requirements and relationships of each species, including cover and food for normal growth.

Increased knowledge of fish biology is needed to put commercial production of fish in farm ponds and lakes on a paying basis.

SOUTHERN ILLINOIS UNIVERSITY, CW-1-70

Fawn mortality on Crab Orchard National Wildlife Refuge.

R. E. HAWKINS and W. D. KLIMSTRA

The behavior of white-tailed deer fawns was studied on Crab Orchard National Wildlife Refuge in Southern Illinois from June through October, 1971. The objectives were to determine mortality factors, habitat utilization, and social relationships of young fawns (fig. 27). Eighteen fawns were captured during this study. Additionally, 26 were captured and marked during the fawning seasons from 1968 to 1970 and in 1972. All 44 fawns captured between 1968 and 1972 were used to determine the total rate of mortality of fawns.

Of the 18 fawns captured in June, 1971, 17 were marked with radio transmitters. At capture, the average age of these fawns was 4 days. Based on three aging criteria, none was judged to be older than 7 days. Thirteen transmitters that failed operated for an average of 120 ± 77 days, which is 46 ± 31 percent, of the predicted battery life.

Between 1968 and 1972, seven of the 44 marked fawns, 15.9 percent, died before reaching 6 months of age. No predation of fawns was observed.



Figure 27. White-tailed deer fawn under examination. Southern Illinois University, CW-1-70

Maximum movements of fawns in June and activity radii in every month except July indicated that male fawns were more mobile than female fawns. But there was no significant difference ($P > 0.05$) in the mean size of home range between males and females. However, in all cases, male fawns used larger areas than female fawns.

There were no definitive habitat use trends in June and July. In September and October, most fawns spent daytime hours in deciduous woodland and nighttime hours in forbs, grasses, and red clover.

UNIVERSITY OF MAINE, 5005

Relationships between white-tailed deer and forest vegetation.

S. D. SCHEMNITZ and F. F. GILBERT

Relatively little work has been done on the impact of fertilization of young tree sprout stands in relation to the changes in nutrient content for deer browse. A hardwood ridge in central Maine cut between 1963 and 1967 was treated

in a randomized block design with various combinations of urea (45 percent nitrogen), triple superphosphate (46 percent P_2O_5) and muriate of potash (60 percent K_2O). These fertilizers were applied at the rate of 150 pounds per acre.

Vegetation on fertilized plots responded to nitrogen fertilization by having consistently and significantly higher crude protein levels. Response to phosphorus was variable, and potassium uptake by vegetation after fertilization was negligible. In vitro digestion trials of white-tailed deer showed no consistent differences in digestibility because of fertilization. However, balsam fir, presumed to be a non-preferred deer browse in Maine, was found to be significantly more digestible than either red maple or beaked hazel.

UNIVERSITY OF MONTANA, 3002

Impact of logging on the elk population in the Sapphire Range of western Montana.

R. R. REAM

A study was initiated in 1970 to determine the environmental requirements of elk and the influence of forest land management on elk in the Sapphire Mountains near Missoula, Montana. Specifically, the impact of roading and timber harvesting on big game populations is being studied. In 1971, radio transmitters were placed on three cows and four bulls, and each animal was located by airplane flights 9-10 times each month through summer and fall. Animal movements through the study area have been observed and a preliminary analysis of the relationship of animal locations to habitats has been completed. From June through November 1971, 53 flights resulted in 306 animal locations. These months represent the time period when the animals are on their summer and fall range. More intensive work on elk use of their winter range is being completed. In the winter and spring of 1972, 10 additional radios were placed on elk, and flights were made every 3 days during the summer and fall months. Useful results should be available within the next 6 months. The study is being made in cooperation with the Montana Fish and Game Department, Region I of the Intermountain Forest and Range Experiment Station, of the U.S. Forest Service, and Missoula District of the Bureau of Land Management.

NEW YORK CORNELL UNIVERSITY, 147553

Wildlife habitat changes resulting from the revegetation of abandoned farmland.

J. W. CASLICK

This study examined the use of time-lapse aerial photography in measuring upland wildlife habitat changes. A system of ground cover classification was developed, and procedures were devised to convert the information to both cover maps and computer data. These procedures were then applied to the entire land area of Tompkins County, N.Y. (314,240 acres), where about 75 percent of the land has been retired from agricultural use since 1900.

Based on 1968 aerial photographs, each 1/100th square kilometer (about 2-1/2 acres) in the county was classified as being predominantly in one of six vegetative cover classes. Ten percent random sampling of 1938 and 1954 aerial photographs provided comparative data from which rates of forest regeneration were developed for the 30-year period. These data were further examined for correlation to six ranges of soil pH, six soil drainage classes, and three physiographic positions (hill, through-valley, and plain).

During the study period, cultivated land decreased about 10 percent, while acreage in full forest cover increased 6 percent. The extent of the intermediate four vegetative cover classes varied considerably through time. The net loss was 15 percent in acreage having less than 50 percent crown cover, and the net increase was 17 percent in acreage having more than 50 percent crown cover. The rate of crown cover change was found to be remarkably constant, increasing about 1 percent each 3 years.

These findings indicate that the techniques developed in the study are useful for determining long-term trends in vegetative cover conditions over large areas. The methods may also be useful in studying the effects of site factors on rates of plant succession.

UNIVERSITY OF RHODE ISLAND, 953

Movements of deer related to forest alteration.

J. KUPA

The spatial use and movements of white-tailed deer equipped with radio transmitters have been studied intensively during fall, winter, and spring periods. The deer varied in age and sex. Spatial use, determined by areas within perimeter locations, indicate daily variations of 1 to 177 acres. During 5-1/2 day analysis periods, spatial use varied from 4 to 357 acres. Adults appear to use greater areas than fawns. From fall to spring, a single adult doe changed its center of concentrated use an average of one-quarter mile each 5-1/2 days. Spatial use and maximum air temperature were also correlated.

The study of vegetation use by individual deer suggests great variation in range composition and relative use of vegetation types. Noted were significant differences in composition of vegetation associated with changes in areas of deer activity. Among six vegetation types known to be included in deer ranges, only one, young hardwoods, was common to all ranges and was the most often frequented. Usually, this type was the oak species, 10-20 feet high. The crown closure was 75-100 percent. Under controlled pen experiments, efforts were made to secure data on deer behavior via broadcast microphones attached to deer collars. Twenty behavioral activities ranging from apple eating to body licking were distinguishable from sonograms of the recorded data.

Signal strength was reflected as amplitude changes in received radio signals from deer in a study pen. Several activities of the deer are readily distinguishable when the animals are equipped with transmitters that have a free antenna of 10" in length. Walking, running, and eating are among signals that are separable.

UNIVERSITY OF TENNESSEE, 12

Ecology and behavior of the black bear in the Great Smoky Mountain National Park.

M. R. PELTON

A total of 32 bears were captured and tagged during 1972 in the Great Smoky Mountain National Park. Besides having its ears tagged and its lips tattooed, each animal was injected with minute quantities of one or two of four different radioisotopes. These served as a method of tagging the feces. Every 2 weeks, researchers hiked 10 index trails covering 158 miles. They recorded the location of each of 311 scat found and collected the scat. These scat are now being analyzed for isotope content. A total of 500 bear observations were made by park personnel, backpackers and project personnel; 173 observations were of previously tagged animals. Radio transmitters were attached to five bears, three of whom are presently being monitored for movement data. Enclosure studies on behavioral development in five young bears continues (play, social interaction, locomotion, postures, etc.). Equipment has been developed for perceptual studies and food preference testing. Filmed records were made of penned and free-roaming bears; single-frame analysis is in progress.

Preliminary data from population estimates indicate that the bear population has increased each year since 1968. Data on movements reflects a restricted home range for adult females in summer (radius of less than 1 mile). There is apparently no location on the Tennessee side of the Park (250,000 acres) where transplanted adult males can be put that they will not return to their original point of capture. Behavioral evidence indicates that black bears have color vision, and that they exhibit predictable behaviors through facial expressions and body postures. The bears do not show a preference for herbaceous plants, which represent a major portion of their diet in the Park in the spring.

UNIVERSITY OF VERMONT, 19

Seasonal carrying capacity of spruce-fir-northern hardwoods for deer in Vermont.

T. W. HOEKSTRA

Since 1971, necessary facilities have been developed and extensive-type surveys have been made to provide preliminary information on study areas and on the physical condition of Vermont deer. A 200-acre fenced enclosure was constructed on State and private land that met the criteria for this study. Captive deer have been tamed for use with a leash and in free-ranging feeding

and food habits studies. Seasonal food habits of leashed and free-ranging tame deer are being compared with contents of rumen. Sixty-six deer that were killed by automobiles and dogs or that starved to death in the spruce-fir-northern hardwood habitats provided rumen contents for analyses of seasonal food habits and for measures of seasonal changes in physical condition. Rumen content analyses are incomplete and sample size for physical condition parameters are inadequate for analysis by deer sex and age classes. Additional samples are being collected.

VIRGINIA POLYTECHNIC INSTITUTE, 636121

Effects of selected disturbance treatments in oak-hickory stands on deer browse.

B. S. McGINNES and H. S. MOSBY

An estimate of browse production was made in undisturbed forest stands of 40 to 60-year old oak hickory, poplar, and white pine in the Broad Run Research Area. The figure was 9.1 ± 1.1 lbs/acre of oven-dried browse. Later work determined that browse production per acre varied widely in cut areas and depended on the degree of cut and the number of years since the harvest. For example, a 30-percent basal area removal, 1 year after the cut, gave 31 ± 6 lbs/acre of browse; however, an 80-percent basal area removal made 4 years after the cut produced 246 ± 63 lbs/acre. Thus, heavy cutting produced a superabundance of browse for deer in the Appalachian hardwood forest types. Subsequent studies indicate that the shape and size of clear-cuts are of primary consideration in their influence on deer and other forest wildlife. Finally, studies recently completed of the food habits of deer clearly indicate that hardened woody twigs are not a significant food item (only 2.3 percent) for deer in the Southern Appalachians. We conclude that clear-cuts, in small, well-distributed blocks, are of greater value to deer for the forbs, grasses, and other herbaceous materials produced in these cuts rather than for the tremendous amounts of browse which they generate.

Deer food habits indicate that leaves, both green and dry, are ingested in significant quantities. Thus, a study was made in which the nutrient content levels of sourwood leaves were followed from the bud stage through the decomposition of the dry leaves.

VIRGINIA POLYTECHNIC INSTITUTE, 636136

Simulations of forest game population structure and dynamics.

R. H. GILES, JR.

This study was designed to gain insight into the characteristics and processes of game and other wildlife populations, particularly to determine how forest management would affect these two areas. The insights gained are then used to develop computer-based decision aids for foresters and wildlife managers.

In the past year, State biologists and their assistants measured the chest diameter (called heart-girth) of 528 deer and they developed a regression equation that allows deer weight to be estimated. The technique also allows weight data to be more readily collected. Trends in herd weight are used as an index to herd health. Also, weights by sex and age are needed to model the forage energy requirements of deer herds, to determine how well this forage may be produced by forest practices, and to discover the tradeoffs involved.

A graduate student, Mr. E. B. Rayburn, in a project cooperatively supported by the U. S. Fish and Wildlife Service, developed a system for improving decisions to acquire public land for wildlife, primarily deer. The system is based on concepts of bioenergetics and allows comparisons between areas based on annual net energy requirements for deer.

Preliminary analyses of deer poaching that was noted were submitted to the Virginia Game Commission. A data base, descriptive of the time, location, and people involved in known deer spotlighting is now complete and analyses are in progress leading to simulation of this mortality factor.

ADDITIONAL PROJECTS

UNIVERSITY OF CONNECTICUT, 376

Habitat analyses of two northeastern cottontails.

R. D. McDOWELL

UNIVERSITY OF FLORIDA, 1032

Ecology of wildlife using sites prepared mechanically for pine planting.

S. L. BECKWITH

UNIVERSITY OF GEORGIA, 30

Biological and ecological aspects of fish and wildlife management in Georgia.

J. H. JENKINS, R. L. MARCHINTON,
E. E. PROVOST, and R. G. DUDLEY

UNIVERSITY OF KENTUCKY, 608

Forest wildlife habitat analysis.

R. B. HEILIGMANN

LOUISIANA STATE UNIVERSITY, 1510

Population studies of woodcock in Louisiana.

R. B. HAMILTON

LOUISIANA STATE UNIVERSITY, 1525

Distribution and population dynamics of the wood duck.

R. B. HAMILTON

LOUISIANA STATE UNIVERSITY, 1551

Monthly availability and use of browse plants by deer in bottomland hardwoods.

R. E. NOBLE

UNIVERSITY OF MASSACHUSETTS, 5

Food and shelter requirements of ruffed grouse in relation to energy regimes.

F. GREELEY and J. S. LARSON

UNIVERSITY OF MASSACHUSETTS, 12

Man-animal interactions in the Northeastern forest environment.

J. S. LARSON

MICHIGAN STATE UNIVERSITY, 982

Ecology of shrubs with high wildlife food and aesthetic value.

L. W. GYSEL

MISSISSIPPI STATE UNIVERSITY, 805

Effects of stand conversion on wildlife populations.

C. J. PERKINS, G. A. HURST,
D. H. ARNER and J. C. JOHNSON

UNIVERSITY OF NEW HAMPSHIRE, 8

Energy requirements of deer in natural habitat.

W. W. MAUTZ

NEW MEXICO STATE UNIVERSITY, 2

Seasonal distribution of mule deer in relation to selected browse species and availability of water.

V. W. HOWARD, JR., and C. T. ENGELKING

STATE UNIVERSITY OF NEW YORK, 904-3-1

The chemistry of aquatic plants.

R. T. LaLONDE

NORTH CAROLINA STATE UNIVERSITY, 4026

Forest wildlife studies-gray squirrel.

F. S. BARKALOW, JR.

OKLAHOMA STATE UNIVERSITY, 1442

Compatibility of game and timber production on intensively managed lands.

J. L. TEATE

PENNSYLVANIA STATE UNIVERSITY, 2033

The ecology of the Pennsylvania elk herd.

J. L. GEORGE and J. B. WASHKO

UNIVERSITY OF RHODE ISLAND, 955

Wildlife telemetry in forest environments.

E. F. PATRIC and R. W. SERENBETZ

UNIVERSITY OF TENNESSEE, 3

Quail management on forest and associated lands in west Tennessee.

R. W. DIMMICK

UNIVERSITY OF TENNESSEE, 6

Wood duck ecology on rivers and impoundments in east Tennessee.

R. W. DIMMICK

UNIVERSITY OF TENNESSEE, 11

Physiological response of wildlife to different forest and associated habitats.

M. R. PELTON

UNIVERSITY OF VERMONT, 22

Home range studies of fisher (*Martes pennanti*) and selected prey species.

R. W. FULLER

VIRGINIA POLYTECHNIC INSTITUTE, 636124

Effect of nutrient levels of reproductive function in white-tailed deer.

R. L. KIRKPATRICK

VIRGINIA POLYTECHNIC INSTITUTE, 636153

A model for improving allocation of wildlife management funds applied to deer management.

E. F. BELL

VIRGINIA POLYTECHNIC INSTITUTE, 636184

Habitat manipulation effects on forest wildlife production and harvest.

H. S. MOSBY, B. S. MCGINNES,
and J. B. WHELAN

VIRGINIA POLYTECHNIC INSTITUTE, 636201

Ecological influences on health and reproduction of wildlife in southern forest habitats.

R. L. KIRKPATRICK and P. L. SCANLON

WEST VIRGINIA UNIVERSITY, 7

The use of sonagram analyses as a possible technique for censusing game birds.

D. E. SAMUEL

WEST VIRGINIA UNIVERSITY, 9

Effects on highways on wildlife and hunters.

E. D. MICHAEL

UNIVERSITY OF WYOMING, 31-0070

Ecology and carrying capacity of summer elk range.

A. A. BEETLE and M. MAY

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FOREST RECREATION AND AESTHETIC AND OTHER LANDSCAPE VALUES

As we learn more of man's outdoor recreational needs through sociological and psychological studies, we find that the natural forest landscape provides many alternatives to meet these needs. However, many forest ecosystems are delicate and require careful management and monitoring. Outdoor forest recreation, as now enjoyed by the urban population, places severe stress on the forest resource by compacting the soil, wounding trees, and trampling reproduction. It is imperative that managers seek a balance between the users and the forests they enjoy so much. The cityscape also benefits from research that provides shade and ornamental trees to enhance community and urban environments. Earlier experience with shelterbelt trees in the Plains States, where certain planted trees grew and survived under a variety of stress conditions, is providing a foundation for current research. Important now and in the future are programs designed to breed and select trees for urban conditions and to maintain them in a healthy condition.

OUTDOOR RECREATION

Research Problem Area 902

Outdoor recreational research provides information to guide the use of management of forest and rural lands for recreation, and to help coordinate this use with other uses of land. The research involves problems in management of the resource and socioeconomic relationships of users to the resource. Recreation demands continue to increase, and they are becoming more varied and more complex, at a time when pressure on all land resources is accelerating.

Management of the forest recreation resource in Arizona.

L. D. LOVE and A. J. SCHULTZ

A study of the alteration of soil properties in campgrounds was completed in August 1972. The objectives of this study were (1) to investigate and compare selected physical properties of the soil in a heavily used recreation area with the same properties of soil in a relatively undisturbed area, (2) to determine the relationship of these physical properties to soil moisture content, and (3) to identify prediction equations that may be used to easily compute soil moisture content, given values for specified soil physical properties. A publication reporting results is in progress.

The study of policymaking in water salvage projects is being continued. The policy of phreatophyte removal is being examined. This study will focus on the use by natural resource managers of scientific data in policymaking in an area of scientific uncertainty and public controversy.

UNIVERSITY OF CONNECTICUT, 390

Role of the forest in open-space planning in eastern Connecticut.

M. J. GRATZER and R. D. McDOWELL

Open-space resources (quantity, quality, and ownership) of a 44-square-mile study area have been inventoried, described, and tabulated. It was found that forest covers 73.9 percent of the area and is the most important visual feature of the landscape. Forest and residential use are interrelated in the study area; thus, the dominant land use is "residential forest." More than 80 percent of the forest is in extremely fragmented private ownership; 3000 owners each hold an average of 6.9 acres of land.

A mathematical model of landscape preference, developed for planning purposes, has been tested. The results indicate that the model, with some modifications, could be a reliable tool in landscape management and in decisionmaking.

The adaptation of an eye-movement recording system to esthetic measurement of the environment has also been investigated (fig. 28). Recording eye movements of respondents over photographs of landscapes helps to explain the pattern of visual perception of the physical environment. Results indicate that an instrument based on the principle of corneal reflection is suitable for mass use and it requires no clinical facilities. In addition, a high level of accuracy and reproducibility was achieved in the 121 tests that used this technique. The scanning patterns of respondents were highly individual, but consistent. Each subject maintained his own scanning speed, regardless of pictorial content of the test photographs. There was a definite relationship between pictorial composition and fixation sequence.

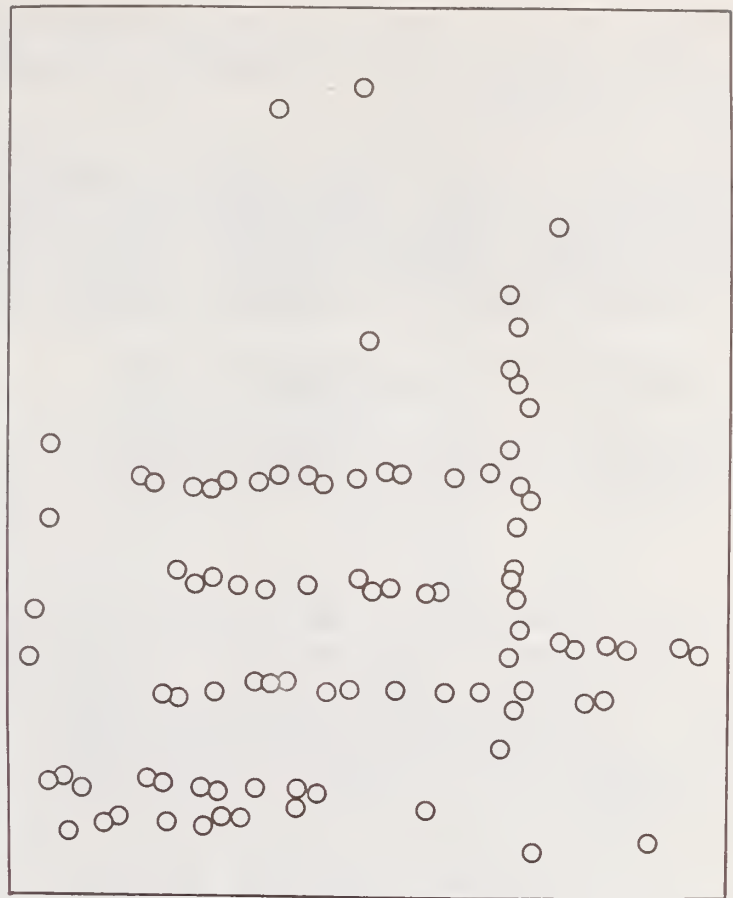


Figure 28. A typical landscape in eastern Connecticut. The diagram shows how this landscape was visually perceived by a respondent. University of Connecticut, 390.

LOUISIANA TECH UNIVERSITY, 8

Status of outdoor recreation economics knowledge.

E. F. HASTINGS and L. P. BLACKWELL

The increased interest in the application of economic theory to outdoor recreation problems indicates the need to economically justify the expenditure of public funds and to obtain additional funding. The purpose of this project is to identify the economic applications to outdoor recreation problems, to classify the areas of application, and to summarize the information obtained into a statement concerning the status of outdoor recreation economics.

Based on reviewed publications dealing with the subject area of outdoor recreation economics, the volume of papers per year increased from three in 1965 to 58 in 1971. A CRIS computer printout listed 123 research projects currently being conducted in the general field of recreation economics. Over 200 publications have been reviewed and compiled into an Annotated Bibliography of Outdoor Recreation Economics. This publication is currently in draft form.

Response to correspondence with persons whose expertise is or is related to outdoor recreation economics showed a need for a symposium in outdoor recreation economics. This symposium would provide a common area for researchers, teachers, and recreation resource managers to exchange ideas and concepts, to discuss

needed areas of research, and to establish lines of communication. To date, two conferences have been held to discuss the possibility and objectives of such a symposium.

The examination of publications, research progress reports, theses, and dissertations, plus the communication by correspondence or conference with professionals, should provide a basis with which to document the application of economic theory to outdoor recreation problems.

MISSISSIPPI STATE UNIVERSITY, 1121

Personality and forest recreation.

H. S. BHULLAR

Volunteer subjects in the study of personality and forest recreation were 488 college students from various universities and colleges in Mississippi. Of these, 303 persons were white, and 185 were black. The students completed two forms: an Outdoor Recreation Activity Questionnaire (ORAQ) designed to quantify participation in selected recreational activities and the Edwards Personal Preference Schedule (EPPS), which measures 15 personality variables or needs.

In white males, the top five activities were: hunting small game, attending outdoor sporting events, fishing in lakes, bird hunting, and walking for pleasure. For black males, the top five activities were: attending outdoor sporting events, touch football, walking for pleasure, softball, and bicycling.

The scores for the needs as measured by the EPPS were also rank ordered. Differences in the mean scores and the rank orders for all four groups were noted. Heterosexuality rated highest for white males and for white females. For black males, the need for order was highest, whereas for black females, aggression was highest. Dominance was rated the lowest need for white males, white females, and black males. The need for exhibition was expressed as the lowest by black females.

By Canonical Correlation analysis, activities and needs were clustered into meaningful groups. Need clusters were correlated with activity clusters to study their relationships. For example, for white males, picnics, leisure walks, and walking for pleasure comprised one activity cluster which was significantly related to the need cluster of intraception and (-) succorance. For black males, the need-activity relationship was entirely different. Boating in large reservoirs, horseback riding, swimming in lakes, motorbiking on streets, and fishing in large reservoirs were related to the need cluster of affiliation, nurturance, and (-) aggression.

PENNSYLVANIA STATE UNIVERSITY, 1836

Wildland recreational management.

J. L. GEORGE and G. W. WOOD

Surveys of users of the central 50,000 acres of the Quehanna Wilderness Area show persons/1000 acres are: 50 during buck season; 25, bear; 12.5, antlerless deer; 2.5, turkey; 1, small game and spring fishing; 0.5, snowmobiling and berry picking; and 0 for much of the year. Numbers vary by a factor of 10 from year to year. Hunters concentrate in areas where game abounds and along roads, pipelines, and rights-of-way. Peak hunter densities have been correlated with two hunter fatalities. Buck and bear seasons attract hunters from hundreds of miles away--20 percent from out-of-State.

Deer populations have varied by a factor of 4 from 70/1000 acres (fall 1968) to 16/1000 acres (March 1970). Winter mortality has varied from 108/1000 acres in 1970 to 2.3/1000 acres in 1972. Observations of marked animals indicate that the herd is well distributed in summer and fall. The animals concentrate on clearcuts in winter and early spring, and retreat to valleys (3 percent of the area) in deep snow. Most deer spend their life on about 1000 acres.

Turkey populations have varied by a factor of 15. Populations had increased to 7/1000 acres by fall 1972. Also at that time, 70 turkeys were marked and equipped with instruments. Winter populations, often as entire flocks, move 7 or 8 miles to major valleys. About 0.5/1000 acres remain on the plateau. Spring populations of 1+/1000 acres are well distributed, whereas summer populations use forest openings, including pipelines and clearcuts, until fall. Critical aspects of management are winter survival and brood production.

PENNSYLVANIA STATE UNIVERSITY, 1842

Effects of land-use changes on the scenic qualities of Pine Creek, Pa.

P. W. FLETCHER

Most of the field work has been completed to determine the following:

1.--Sandy streambank soils were found able to accept and to renovate effluent from conventional septic tank sewage systems. Field tests were made of water percolation rates along 36 miles of stream, and both field and laboratory tests were made in large and small lysimeters of the changing rate of uptake with time of various effluent chemicals (notably P, N, and C) and bacteria (total and fecal coliform and fecal streptococcus).

2.--The flood plain was subdivided into several risk zones along 36 miles of stream, based on (1) the flood crest level of tropical storm Agnes (calculated as a 1-in-400-year event) and (2) analyses of 50 years of U.S. Geodetic Survey records at each of two stream gaging stations.

3.--Relationships were found between coal mine acid gradient down a tributary stream and its benthic mass or invertebrate population.

Citizen concern, based partly on project data to date, led to the formation of a joint Local-State Task Force on Pine Creek to begin action, including law enforcement, to protect the watershed's scenic resources. Subsequently, the Pennsylvania State University established a center for the Study of Environmental



Figure 29. Pine Creek is a candidate for designation as a Wild and Scenic River. Pennsylvania State University, 1842.

Policy. The University chose the Pine Creek watershed as the first study area (fig. 29) and allocated funds for socio-economic-political studies.

ADDITIONAL PROJECTS

UNIVERSITY OF ARIZONA, 2016-4168-014

Forest recreation demand analysis.

D. A. KING

CALIFORNIA STATE UNIVERSITY, 13

The optimum mix of undeveloped and developed land within a hyleopolis.

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Psychometric tests of user attitudes concerning primitive wildlands in northern California.

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IOWA STATE UNIVERSITY, 1824

Demand Patterns for outdoor recreation in Iowa.

H. H. WEBSTER

IOWA STATE UNIVERSITY, 1949

More effective regional development of forest and recreation resources in Iowa.

H. H. WEBSTER, J. C. MEADOWS,
and G. L. BULTENA

UNIVERSITY OF MAINE, 5010

Recreation and forest land use planning.

J. C. WHITTAKER and T. J. CORCORAN

MICHIGAN STATE UNIVERSITY, 1038

Recreational trail use and user characteristics in Michigan.

L. MONCRIEF

MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3314

Effects of visitor impact on a nature trail.

C. R. CROWTHER

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Interrelationship of Minnesota recreation system and Voyageurs Park.

L. C. MERRIAM, JR., and T. B. KNOPP

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and V. KURMIS

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NEW YORK - CORNELL UNIVERSITY, 147554

Snowmobiling impacts and resource development.

B. T. WILKINS and T. L. BROWN

NORTH CAROLINA STATE UNIVERSITY, 4032

The evolution of outdoor recreation policy among Federal land managing agencies.

H. K. CORDELL, L. W. MONCRIEF,
and J. G. KINCAID

NORTH CAROLINA STATE UNIVERSITY, 4041

Trends in preferences for selected components of the southern Appalachian developed campsite environment: validity and possible causes.

H. K. CORDELL and S. R. HENDRICKSON

SOUTH CAROLINA - CLEMSON UNIVERSITY, 1

River stage forecasts of five canoe entry locations on the Chattooga River, North Carolina, South Carolina, and Georgia.

G. E. HOWARD

UNIVERSITY OF TENNESSEE, 13

Characteristics of campers in forest recreation areas in Tennessee.

K. F. SCHELL

UNIVERSITY OF VERMONT, 15

Comparative economic analysis of public recreation land in forested areas of Northeast.

F. O. SARGENT

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Outdoor recreation user group conflicts on Vermont forest lands.

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WASHINGTON STATE UNIVERSITY, 62

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TREES TO ENHANCE RURAL AND URBAN ENVIRONMENT

Research Problem Area 905

This research provides some of the scientific knowledge required to maintain or to improve the quality of the rural and urban environment, and to enhance natural beauty through special-purpose tree planting. Technological change is multiplying the need for such planting to screen junkyards and highways, suppress noise, and slow the movement of dust and debris. These trees are also needed for shade, beauty, and shelterbelts to protect crops, animals, and farmsteads. Research is required to find species and techniques so that trees can survive smoke and air pollution, compacted soils, deficient or excess moisture, and other adverse conditions. The end product of concern in this research is a standing tree that will enhance the environment.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION, 416

Attenuation of noise by vegetation.

D. E. AYLOR and P. E. WAGGONER

Physical principles of sound attenuation by vegetation and soil have been explained, and these results have been used to evaluate attenuation for various configurations of soil and plants. Scattering of sound energy due to reflection is the primary mechanism causing attenuation. Foliage and stems diffuse concentrated sound effectively but absorb little of it. Therefore, vegetation gives best results when it is used as a screen on a line of sight between a concentrated source of sound and the listener. Sound fields that are already diffuse are reduced relatively little. Because the ground is porous, it reflects sound only after a slight delay, during which the air in the pores is being compressed. Combined with the longer distance travelled by the reflected beam, compared with the direct beam, this delay causes acoustic interference at the receiver. In general, the more porous the soil, the longer is the delay in compressing air in its voids. The result is that the peak attenuation occurs at lower frequencies over more porous soils. A functional relationship between attenuation and sound frequency, leaf width, leaf area density, and breadth of canopy was found. In addition, attenuation data for a variety of ground surfaces have been obtained. For illustration, the attenuation has been calculated of individual octave bands for real noise sources. The results give a basis for selecting a particular planting or ground treatment, depending on the sound spectrum of the annoyance, and they provide reasonable estimates of the amount of sound reduction to be expected.

Tree breeding.

W. T. BAGLEY and D. P. COYNE

At Lincoln, growth, phenological, and morphological characteristics have been compared for progeny of 100 trees from 30 stands of green ash scattered throughout 7 States of the Great Plains Region. The further north the origin, the slower the trees grew. Trees from eastern Nebraska and from South Dakota grew taller than trees from the western parts of these States. Progeny of a Minnesota origin grew taller than those from Nebraska and the Dakotas.

Northern trees initiated leaf buds earlier in the spring and dropped them earlier in the fall than those from the south. Winter injury was noted on the fastest-growing trees from Oklahoma and Texas.

Progeny from a provenance planting of 12-year-old green ash responded in the same manner as their parents and other seedlings of similar geographic origin. Natural cross pollination among different sources growing side by side apparently did not occur, because of differences in dates of anthesis.

Detailed data are being recorded on a provenance planting of 8-year-old cottonwood, containing 119 open-pollinated families of two to six clones each. The sex of about one-third of the clones has been identified. Within families, considerable variation has been found in morphology of flowers, fruit, leaves, and bark. Open-pollinated progeny are being observed in the nursery bed. Inter- and intra-provenance cross pollinations are being planned.

Seedlings from south of 33° latitude suffer repeated winter injury. Growth rate and phenological observations show a north-south and east-west variation pattern. Resistance to leaf rust and stem canker is being noted.

NORTH CAROLINA STATE UNIVERSITY, 4031

Management characteristics of urban forest space.

J. O. LAMMI

The city of Raleigh, North Carolina (population around 120,000) served as a case study in urban resource management. An analysis of air photos showed that, of the surface area within the city limits, nearly 17 percent was forested and 4 percent was nonforest open space. The open space was relatively the smallest in the central business district and in high-value residential areas, and it was the largest in the less affluent sections. The lack of public control of land use, either through ownership, lease, or zoning, results in ongoing attrition of open space and mismanagement of natural resources. Interest and attention to resource management is increasing notably, both within the municipal administration and among landowners. The resources receiving particularly close attention are soil and the forest. Previous mismanagement and lack of attention to the needs of the soil resource has caused costly siltation of waterways and ponds. Regulations for erosion prevention are now

being more rigorously administered, and soil characteristics are receiving closer attention in zoning and in issuing permits for development. Forest resources are being utilized more adequately from the esthetic and pollution-prevention points-of-view. Wood is also better utilized during the real estate developmental activity. The municipal authorities as well as the citizens need more information about green space resources and their management.

ADDITIONAL PROJECTS

UNIVERSITY OF DELAWARE, 759

Nutrition and management of woodland trees of ornamental value.

C. W. DUNHAM

UNIVERSITY OF MICHIGAN, 23

Development of an information-inventory system for managing urban forests.

J. R. BASSETT

UNIVERSITY OF NEBRASKA, 20-23

Windbreak shelter effects.

W. T. BAGLEY and R. E. NEILD

NEW JERSEY - RUTGERS UNIVERSITY, 257

The effects of environmental stresses upon the oak-chestnut forests of Blue Mountain, Pennsylvania.

B. B. STOUT

NORTH DAKOTA STATE UNIVERSITY, 12-1

Shelter belts in North Dakota.

E. P. LANA

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WRIGHT, J. W., F. H. KUNG, R. A. READ, R. J. STEINHOFF. and JOHN W. ANDRESEN

Nine-year performance of Pinus flexilis and Pinus strobiformis progenies in Michigan and Nebraska. *Silvae Genetica*. Vol. 20, No. 5/6. pp. 211-214. 1971.

ALTERNATE USES OF LAND

While our Nation's land prices continue to rise and additional investment alternatives are becoming available to the general public, more attention is going to studies of the multiple-use potential and alternative uses of forest land. Utilization is diversifying on increasing acreages of wooded land formerly used exclusively for timber production. This change is taking place because of the changing emphasis of absentee landowners who have a variety of managerial goals. No longer is forested land bought and sold for timber values alone. Uses for recreation, second homes, aesthetic purposes, wildlife management, and watershed protection are among the alternatives now employed by owners who are mostly urban residents.

More information is being provided to the absentee owner through forestry research which includes: inventory studies and appraisals of current and potential land uses, evaluation of economic benefits and expenses, and estimates of future land requirements by a shifting population. Further work involves determinations of the relative efficiency of various combinations of measures and programs in meeting projected demands for all forest-based products and services.

ALTERNATE USES OF LAND

Research Problem Area 104

Alternative uses of land need to be evaluated to determine which ones will provide the greatest short- and long-range social and economic benefits. Population growth, advances in agricultural technology, changing consumer demands, urban and suburban growth, needs of people at home and abroad, recreational needs, and other factors--all result in changing the demands on our Nation's fixed supply of land. Soil conservation and water, watersheds,

recreation, and community development programs and policies should be based on the relative advantages of alternative land uses.

UNIVERSITY OF DELAWARE, 715-E

Wild-land ecology and urban impact.

R. E. JONES and R. R. ROTH

A study was started of several factors which may regulate the diversity of the avian community in urban woodlots. The factors are area of woodlot, area-edge ratio, and horizontal and vertical vegetation complexity. Seven study areas having deficiencies in these characteristics were selected. A census was made of populations of breeding birds, by the singing male method. Vegetation was sampled by a modified point-sampling method that provided data to be used for calculating indexes of vegetation complexity.

The annual census of yellow jacket nests in the University of Delaware Woodlot found three nests in 1972, compared with 50 in 1971. No destruction of nests by skunks was found. The annual censuses, mapping of nest locations, and study of predation by skunks are parts of a long-term study to find factors which affect habitat selection and regulate yellow jacket populations.

Another study attempts to evaluate whether squirrels in high populations exert a significant effect on oak reproduction. Part of the study concerns the responses of the squirrels to spatial variation in food abundance in the woods. Home range and population data are related to mast data on five 2.5-acre plots in different forest types of the 35-acre woods.

UNIVERSITY OF HAWAII, 159

Agricultural potential and alternative uses.

H. IKAWA and G. UEHARA

Tropofolists are naturally forested organic soils of intertropical regions which occur on lava flows in areas with very high and well-distributed rainfall. This soil type covers 11 percent of the State of Hawaii. Rainfall, soil temperature, and texture of the underlying rock are three site parameters which govern the use potential of Tropofolists. Because of the highly porous nature of the underlying lava, which in most instances occurs within 4 inches from the surface, annual rainfall must exceed 80 inches before this soil can be used for crop production. In areas with summer rainfall maxima, 50 inches of rainfall is as effective as the 80 inches in areas with winter rainfall maxima.

Above 2000-ft. elevation, low soil temperatures and excess cloud cover reduce the potential of these soils for commercial forestry or agriculture. In addition, the soil is suitable for use only when the underlying rock is aa--a loose, clinkery, basaltic lava. The soil is less valuable when it occurs on smooth, billowy, pahoehoe-type lava. An estimated 43 percent of the Tropofolists are underlain by aa lava.



Figure 30. The top photo shows freshly cleared forest containing micro-relief of Aa lava flow. This area will be leveled before cropping. The bottom photo is a closeup of a leveled surface ready for planting. Use the 8-inch knife at the bottom of the picture as a scale. University of Hawaii, 159.

Several thousand acres have already been cleared for commercial forestry and for fruit and nut crops. In the land-clearing operation, most of the organic matter is buried and the rest is washed into the subsoil, leaving a rock pavement free of organic matter (fig. 30). Evaporative water loss from organic matter is reduced in these "inverted" soils. Some of the soil organic matter

appears to be lost irreversibly after clearing. The rate of loss under different use patterns is being determined to find a guide to the best use.

Based on knowledge gained in the project, there are about 50,000 acres of Tropofolists suited to forestry or crop production.

LOUISIANA TECH UNIVERSITY, 9

Land use patterns for forested properties in Louisiana.

E. F. HASTINGS and L. P. BLACKWELL

In anticipation of the need for basic data to make land use planning decisions, this project has been initiated to document the current management objectives for privately owned forest land in Louisiana. The procedure involves determining trends in management objectives, finding purposes of ownership, and discovering landowner reaction to possible land use controls or regulations.

A basic literature search of publications relating to land use patterns, inventory, planning, classification, and capability revealed more than 150 articles, pamphlets, and books discussing the land and its resources, and the problems associated with inventory, management, and planning or zoning.

The grid system established by the U. S. Forest Service Resource Inventory is being used to locate sample points so that data obtained during this study can be correlated with data obtained by the U. S. Forest Service.

The questionnaire survey form will be field tested early next year. A conference with other researchers in this subject area will assure that data obtained can be grouped for multistate or regionwide analysis if this grouping is desired.

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COLORADO STATE UNIVERSITY, 335

Effects of urbanization on the use of resources of a mountain watershed.

R. B. HELD and H. R. ALDEN

UNIVERSITY OF MARYLAND, A-18-BH

Effects of tax policies on forestry production in Maryland.

S. ISHEE

NORTH CAROLINA STATE UNIVERSITY, 4005

Wood fiber properties and paper quality.

A. C. BAREFOOT

MULTIPLE-USE POTENTIAL OF FOREST LAND AND EVALUATION OF FORESTRY PROGRAMS

Research Problem Area 903

Most forest areas and related resources can be devoted to widely varying uses, depending on the owner's objective and the allocation of investments for resource development. On more than 300 million acres of national forests and other public lands, for example, guidelines are needed to determine the best combination of uses or systems of managing forest land for timber, water, forage, recreation, wildlife, or other purposes.

Forestry programs to increase the production of timber and related forest resources need to be evaluated to determine their relative costs and effectiveness. These programs cover a wide range of activities, including protection against fire, insects, and disease; reforestation; improvement of timber stands; and improvement of timber harvesting.

SOUTHERN ILLINOIS UNIVERSITY, 69-R-B

A study of the trend in forest land exchange in Southern Illinois.

R. M. MISCHON

A total of 228 landowners who had acquired land in 1968 in seven counties (Alexander, Hardin, Johnson, Massac, Pope, Pulaski and Union) responded to a mail-out questionnaire. Over half the owners were less than 45 years of age, and one-fourth were under 35. These new landowners were mainly nonfarmers. Nearly three-fifths were businessmen, professionals, or other nonfarm wage earners. More than one-third had received some college training, and two-thirds said that their family income was over \$8,000 a year. Over one-fourth earned more than \$15,000 annually.

Almost two-thirds of the land transactions involved tracts of less than 100 acres in size. However, these tracts accounted for only one-fifth of the acreage in the sample. The average size of the tracts was 140 acres. Woodland acreage averaged around 40 acres. Over nine-tenths of the owners had purchased their tract directly from the previous owner, and a third said that they learned about the availability of the tract through word-of-mouth (from friends, neighbors, or others).

The new owners gave four major reasons for acquiring land in the seven-county area. These reasons were: (1) agricultural potential, (2) residence, (3) tract adjacent to land already owned, and (4) a place for family outdoor recreation. Analysis of the data revealed a number of differences in the way that these acquisition groups currently managed their land and in how they viewed the future potential of their woodland.

Planning procedures for public forests.

R. J. MARTY

The planning process is meant to identify feasible paths of forest development and to determine which of these is most in the public interest. Better planning procedures for public forests requires a more accurate and flexible modeling of biological and ecological processes within the forest property. This model should be integrated with a more comprehensive appraisal of the external forces which define the relative social value of alternate uses and development paths.

The planning procedure under development in this research project is relatively general in nature so that it can be adapted to a wide range of specific conditions. Planning is divided into two subtasks: the identification of physical production functions and cost functions, and the estimation of values and costs for outputs and externalities. The procedure integrates functional planning for management sub-units and it indicates the types of information required at each stage in the procedure. The procedure identifies indexes and measures of current and potential productivity, cost and effectiveness, and it provides for interaction with interest groups at each stage.

A basic flow chart model of the entire planning process has now been developed. Detailed procedures for the evaluation stage have been completed. The next stage in further specification will be to apply the process to a specific public forest to identify the degree of sophistication and detail desirable and feasible, based on the planning resources typically available.

UNIVERSITY OF NEW HAMPSHIRE, 6

Forest land resources in the economy of New Hampshire.

B. B. FOSTER

An approach has been developed to quantify the influences for change in the use of forest lands that are under heavy pressure from seasonal homes and recreational developments. Continuous evaluation of land use classes is accomplished by establishing a photo point on one aerial photograph, to use as a base. This photo point is compared with photos of the same point taken in other years. To aid photo interpretation, a transparent overlay was used that had concentric circles of 100 and 200 yard radii (in photo scale). Additional information can be gained by identifying surrounding factors or features which may influence future use. For example, a point within 200 yards of a lake will be under greater influence from recreational development than one not associated with water. Other factors and features which may influence future use include existing houses, roads, recreational areas, ski areas, or areas, of special interest.

The study area was stratified into three strata: points within a mile of a 100+ acre lake, within a mile of a 100-1000 acre lake, and greater than 1 mile from a 100+ acre lake. Thus, the influence of water could be measured. Within these strata a point would be influenced or "occupied" if it fell within 200 yards of a building or within 100 yards of a public road. If the point is greater than 200 yards from either of these man-made features, it will be classified as "occupied", and it will be further designated as to whether it contains forest, cropped agricultural, or idle land.

Early results have shown a greater rate of land use change in the strata surrounding lakes, as would be expected. In the area greater than 1 mile from a lake, houses appear to be built near existing houses and along existing roads; therefore intensification results. However, near lakes, new roads are extended into forest land and groups of houses established; hence extensification results. Projections for future land use class distribution have been made.

ADDITIONAL PROJECTS

COLORADO STATE UNIVERSITY, 328

A model for multiple use resource decisions in the ponderosa pine ecosystem.

H. W. STEINHOFF

COLORADO STATE UNIVERSITY, 353

Management of environmental quality on forested land.

R. S. WHALEY and A. A. DYER

SOUTHERN ILLINOIS UNIVERSITY, 72-R-3

A systems approach to forest resource decision making.

D. R. McCURDY

IOWA STATE UNIVERSITY, 1877

Sampling, estimation and model building for forest resource management.

L. C. PROMNITZ

IOWA STATE UNIVERSITY, 1950

Resource allocation in management of forest lands for multiple objectives.

J. C. MEADOWS and D. W. ROSE

LOUISIANA STATE UNIVERSITY, 1232

An evaluation of forest recreation areas in Louisiana.

R. W. McDERMID

LOUISIANA STATE UNIVERSITY, 1561

Landowner characteristics affecting forest management on small woodlands in Louisiana.

C. B. MARLIN

UNIVERSITY OF MICHIGAN, 18

Informational and structural needs for multiple-use planning on public forests.

W. R. BENTLEY

MICHIGAN STATE UNIVERSITY, 1075

Computer models in the spatial analysis of natural resource economic data.

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The effects of four management systems on wildlife habitat and timber production.

J. W. STARR, J. E. MOAK,
and C. J. PERKINS

MISSISSIPPI STATE UNIVERSITY, 612

Mississippi's private nonindustrial forest landowners.

J. E. MOAK

UNIVERSITY OF NEW HAMPSHIRE, 5

Forest management control in non-industrial woodlands.

R. R. WEYRICK

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Evaluation and projection of the multiple uses of New Jersey's State forests.

R. F. WEST

STATE UNIVERSITY OF NEW YORK, 903-0-4

Management decision models as they relate to multiple-use forest management.

R. E. GETTY and D. A. MORRISON

OREGON STATE UNIVERSITY, F-884

The objectives and management problems of owners of small forest properties in western Oregon.

C. F. SUTHERLAND

VIRGINIA POLYTECHNIC INSTITUTE, 636186

Psychometric evaluation of even-aged forest management.

C. M. NEWTON

WASHINGTON STATE UNIVERSITY, 1969

Systems analysis of a forested watershed.

W. R. BUTCHER, R. A. GILKESON,
and G. A. HARRIS

UNIVERSITY OF WASHINGTON, 27

A systems analysis of the forest ecosystem of the Snohomish River Basin.

J. S. BETHEL, K. J. TURNBULL,
and B. B. BARE

UNIVERSITY OF WISCONSIN, 1714

Economic analysis of alternative forest land-use allocations.

J. D. BRODIE

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Appendix I

INDEX OF PROJECTS BY STATES

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